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BUILDING ACCOMMODATION FOR TECHNICAL EDUCATION

THE twelfth report from the Select Committee on Estimates for the Session 1952–53* records the results of the Committee's examination of the estimates for public education for 1953–54 so far as they relate to technical education. To the report are appended minutes of evidence taken from representatives of the Association of Principals of Technical Institutions, the Association of Technical Institutions, the Federation of British Industries, the Royal Technical College, Glasgow, and of other bodies, as well as of the Ministry of Education and of the Scottish Education Department. Annexes include memoranda on technical education in England and Wales, from the Ministry of Education and, on technical education in Scotland, from the Scottish Education Department. The scientist may also be interested in those on technical education from the Federation of British Industries, on the proposed college of technology at Sheffield and on the extension of the Manchester College of Technology. Taken together, the report and its appendixes give a comprehensive and authoritative, if scarcely concise, picture of technical education in Great Britain, which is relevant to some aspects of the discussion of the development of technological as well as of technical education, and some earlier comments on both are strongly endorsed.

The dominant impression derived from this report is almost exactly that to be derived from the Select Committee's eighth report, dealing with schools: the present rate in Britain of building for educational purposes is quite inadequate for the declared and agreed aims in education. Either those aims must be adjusted or more resources, taken from other activities, must be allocated to the task. That conclusion is not, indeed, specifically formulated by the Select Committee, though it is implicit in its general conclusion, and it stands out clearly in the Committee's comments on unsatisfactory buildings and on new building. Many of the buildings for technical education fall short of the requirements for good educational instruction. "In Birmingham the overcrowded condition of the College of Technology cannot be over-emphasized. Improvisation has been used to the limit. . . . Experimental work in the internal combustion engine department has sometimes had to be stopped in bad weather, owing to the need for covering the machines with tarpaulins to protect them from the rain." To continue the use of such buildings in their present condition much longer, the Committee justly observes, is not only to endanger life and limb but also to risk considerable danger of an eventual increased financial liability. Accommodation is also desperately needed in Sheffield, where the school of engineering is accommodated in converted disused schools and temporary buildings.

* Twelfth Report from the Select Committee on Estimates, together with Proceedings of the Committee of 29th July and the Minutes of Evidence taken before Sub-committee E on 10th June and subsequent days, and Appendices. Session 1952–53. Technical Education. Pp. xxii+173. (273.) (London: H.M. Stationery Office, 1953.) 7*s.* 6*d.* net.

It was admitted by the Ministry of Education in its evidence that almost all provision for construction is now being limited to fields—such as engineering, mining, textiles and buildings—serving industries supplying export and defence needs, and replacement of the many unsatisfactory technical school buildings does not appear to be envisaged. The Select Committee was satisfied that all those concerned, whether in central or local government or in independent establishments, are working in close harmony towards a single goal, and states emphatically that the enterprise being shown in improvization and the determination to overcome all obstacles reflect the greatest credit on all concerned.

This unity and determination may well be due to the general unanimity as to the vital importance of technical and commercial education in the economic struggle with which Great Britain is faced to-day and which so impressed the Select Committee. It is undoubtedly recognized that Britain's competitive power in world markets and the higher productivity of her industries depend largely upon the degree to which technical and commercial knowledge and skill and wider educational opportunities are within the reach of all. This in turn depends largely upon the imagination, skill and ingenuity with which the programme of technical education is planned. Although the demand for all forms of technical education is still increasing, the Committee insists that persistence of the conditions referred to prevents a full return for the money spent on technical education, and that failure to provide satisfactory accommodation retards the national effort.

The present need is for proper facilities—in particular, adequate buildings where technical instruction can be given efficiently; until these exist in sufficient number, a full return will not be realized from public expenditure on technical education. In 1949 it was estimated that provision of minimum facilities for technical education in Great Britain would involve a post-war investment of about fifty million pounds. While this figure would now have to be increased by fifty per cent to allow for the rise in prices and other factors, only about ten per cent of the necessary work has been completed in the past five years. The programme is now running at the rate of four to five million pounds per annum; and this means that the complete programme will not be put in hand by 1959–60 as had been expected.

Nor is this all. The evidence submitted regarding the cost of certain technical colleges, only one of which (Norwich) has been completed since the War, shows that in present conditions continuous building is impossible. Each college is being built in instalments, a process admitted by all to be expensive in money, labour and materials. In spite of every effort by the local education authorities to mitigate the disadvantages of such a system of building by drawing up plans so as to minimize unnecessary work, evidence was submitted of sixty instances of piecemeal building of extensions. The Committee was unable to measure the full extent of the system or to assess the financial loss, not only in building costs but also in the hiring of temporary premises, often unsuitable, the duplication of expensive equipment and the like; but it strongly recommends that the Ministry of Education should first re-examine the method of building in instalments with the view of eliminating to the maximum extent the financial loss entailed, and secondly, consider the possibility of allocating money for building technical colleges to local authorities on a five-year basis.

Both industry and educational authorities favour the system of part-time day-release for technical education, and this also is the form most favoured by the trade union side of industry. A welcome feature of the report is the evidence that this demand for day-release training is increasing, and that it can be met more easily than a demand for evening classes. There is, however, also evidence that demands for places in particular courses in technical colleges are not being met. The Select Committee was unable to investigate the extent of this unsatisfied demand, though it is confident that closer co-ordination at regional levels will help to solve the problem. It recommends that the Ministry of Education should ask the regional advisory councils, through the National Advisory Council, to ascertain the extent of the deficiencies, with the view of determining whether a larger portion of the money available should be used to meet this urgent need.

While in Scotland the practical importance of technical and technological education is becoming increasingly recognized, the Select Committee found that the difficult conditions in regard to buildings which it had noted in England prevailed in Scotland to a more serious and marked extent. This was evident at all levels, both in rural and industrial areas; and although some of the most urgent needs had been met, the quality of some of the provision left much to be desired. Nor could the financial cost or loss in technical efficiency caused by improvizations be measured. The Committee formed the opinion that, in Scotland, building for technical education purposes had been treated by local authorities as second in priority to building for primary and secondary school purposes, and it recommends that the Scottish Education Department should consider whether part of the grant which is made to some local education authorities for educational purposes should be earmarked for the building of new premises for technical education. It also recommends that the Scottish Education Department should consider, in the interests of efficiency, the establishment of a national advisory committee for co-ordinating the efforts of the five regional councils in the same way as is done in England and Wales.

The Select Committee points to the contrast between Scotland where, although the central government is willing to grant the money, the demand for building permission is not forthcoming from the local education authorities, and England and Wales, where local education authorities are pressing for a greater allotment of money and permission to spend, which the central government, because of present economic conditions, often withholds. This may not be entirely fair to Scotland, and has in fact been denied by some local authorities there. It overlooks the

fact that, in being forced to choose between the construction of new schools for new estates and the expansion of technical education, local authorities, especially in Scotland, are forced to make policy decisions that should properly be made at the national level.

Nevertheless, the Select Committee has produced an extremely valuable survey of the present provision in the shape of buildings and accommodation for technical and technological education in Great Britain, and indicated some of its most urgent needs. The report will encourage those who have emphasized the urgency of this problem to redouble their efforts.

THE PSYCHIATRY OF TWINS

Psychotic and Neurotic Illness in Twins

By Eliot Slater, with the assistance of James Shields. (Medical Research Council Special Report Series No. 278.) Pp. vi+385. (London: H.M.S.O., 1953.) 21*s*.

THE mentality of twins gives ideal material for determining the separate influence of inheritance and environment. Even in their case, however, it is not perfect, since the very fact that two children are twins leads to their being given the same sort of background. It was Francis Galton who, in 1883, first directed serious attention to the personality of twins. This he investigated by personal inquiry, and the facts he ascertained from his friends and acquaintances were sufficient to show that uniovular twins not only resemble each other physically, but psychologically also. Moreover, he noticed that some twins resemble each other in developing similar types of insanity as well. Naturally, this attracted the attention of psychiatrists, but not until recently have other than anecdotal accounts of twins been published. During the past thirty years Simens, Newman, Dahlberg, and others have discussed the various problems associated with them, although mainly without complete statistical analyses. In 1930 Luxenburger laid down a more satisfactory basis for their study, and his work has been the foundation of it since. Gedda in 1951 published a very exhaustive examination of the whole matter, and now, finally, we have this excellent publication of E. Slater and J. Shields.

The book is a long study. The first eighteen pages are concerned with previous work on unselected series of psychiatric twins; the next thirty pages describe the nature of the present investigation; and a further twenty-seven pages the clinical findings, five of which are devoted to the summary and conclusions, and twenty-one to genetical notes, age correction tables, finger-print formulæ and a statistical analysis of finger-prints. The rest of the book gives the complete case-histories.

The work was begun in 1936 on some twenty thousand mental patients and was later extended to a number of other mental hospitals as well as the Maudsley psychiatric clinic. The propositi numbered 295 born from multiple births. A great deal of interesting material was unearthed which can, perhaps, be given best by quoting from the authors' epitome. They state: "We found that 76% of the uniovular twins of schizophrenics had schizophrenic illnesses, a somewhat lower concordance rate than that of 86% found by Kallmann. Within concordant uniovular pairs there were often wide differences in the severity of the illness and in outcome. These facts suggest that the genetical causes provide a potentiality for schizophrenia, perhaps an essential one, though environmental factors play a substantial role, which may be decisive in the individual case. Those environmental factors which affect personality and constitution appear to be the most important. Heredity is also an important factor in the causation of affective and organic psychoses. There is a striking contrast between the psychoses on the one hand and the psychopathic and neurotic states on the other. In the latter, uniovular pairs were less frequently concordant, and some of the binovular pairs developed very similar troubles despite big differences in intelligence and personality. The dividing line between adjustment and maladjustment is not so wide as that between sanity and insanity and is more easily over-stepped, so that chance, whether favourable or unfavourable, is more important. However, personality is of even greater importance in these conditions than in the psychoses".

From this very honest and fair summary it can be seen that, although this work has been well worth doing and will, no doubt, be widely quoted extensively in the future, it does not solve the final problem of the nature of the psychoses, and only contributes towards that of the neuroses. Nevertheless it should be read by every psychiatrist interested in the origination of mental and nervous illness. The book is well printed on good paper but provided with an insubstantial cover which soon wore out in reading.

CLIFFORD ALLEN

AN INTRODUCTION TO EMBRYOLOGY

Entwicklungsphysiologie

Von L. v. Ubisch. Pp. 85+16 plates. (Berlin: F. W. Peters, 1952.) 9.50 D. marks.

THIS small book of less than a hundred pages is intended by Dr. L. von Ubisch, a well-known experimental embryologist living in Norway (in the language of which country it was first published), as a brief introduction to what may be called rather more correctly in German than in English, "developmental physiology". For it contains nothing about respiration, nutrition or excretion during embryonic development; it is concerned solely with the early phases of morphogenesis, and even so it has relatively little to say of the physiological mechanism of determination. The emphasis is on normal development, with enough experimental embryology to bring out the differences between eggs of mosaic and regulative type.

The treatment is systematic. First the normal development, as far as larval stages, is given for six forms (*Tubifex*, *Ascaris*, *Platycnemis*, *Paracentrotus*, an ascidian and an amphibian). These are illustrated with a sufficient number of clear drawings, which, however, would have been easier to use if the publisher had printed them on out-folding plates so that they could be studied while the text was read. There follows a systematic description of fragmentation and injury experiments in the different forms, in order to illustrate the varying degrees in which they are capable of regulative development.

Concluding chapters discuss determination itself, the problem of organizers and inductors, gradient

theory, and the colloidal condition of the protoplasm of the cleavage cells, a question which particularly interests the author. He seems to show himself in these sections sometimes rather old-fashioned (for he still believes in "double assurance"), and sometimes bewildered (not inexcusably) by the wealth of information which has accumulated during the past twenty years on the physico-chemical nature of the inductor stimulus. It is one thing to maintain that in the past the intrinsic nature of competence (of a tissue to react), with all that that must imply for protein and surface chemistry, was not sufficiently taken into account; it is quite another thing to fall back, as Dr. von Ubisch does, and many other thinkers who are primarily zoologists do, upon "unspecific stimuli" as the normal mode of action of primary and secondary inductor phenomena. The author is again old-fashioned in his attachment to the gradient theory of Child, and seems unaffected by all the criticisms which physiologists have made of it; but he realizes that it has been absorbed in general field conceptions, which will probably always prove indispensable in this subject. Much more serious is the fact that there is no reference at all to important modern contributions such as those of Holtfreter, Toivonen, Brachet and Yamada.

Joseph Needham

PROGRESS IN LIPID CHEMISTRY

Progress in the Chemistry of Fats and other Lipids (Progress Series.) Vol. 1. Editors: Prof. R. T. Holman, W. O. Lundberg and T. Malkin. Pp. vii+186. (London: Pergamon Press, Ltd., 1952.) 42s. net.

When Dr. H. Schoenfeld died, a new edition in English of the well-known Hefter–Schoenfeld "Chemie und Technologie der Fette und Fettprodukte" was in course of preparation, and it was decided that completed and projected manuscripts should be published as a progress series, of which this is the first volume. The technological contributions will form a companion series.

Since the space available for each contributor is obviously limited, the various chapters are likely to prove of more value to the non-specialist in their particular fields than to the man who is familiar with larger specialized publications. All the contributions are by experts in their field, and all are very readable.

T. Malkin deals with the molecular structure and polymorphism of fatty acids and their derivatives. The chapter is well illustrated with diagrams which, with the simple textual descriptions, make what might otherwise be a difficult subject delightfully lucid. After describing the structure of the unit cell, the discussion of polymorphism follows logically. Thus, the higher melting point of methyl than of ethyl esters is in line with crystallographic evidence of association due to the methyl groups. Alternation of certain properties peculiar to the solid state (for example, melting point) between odd and even members in some series of long-chain compounds (for example, fatty acids and methyl esters) but not in other series (for example, hydrocarbons, alcohols and ethyl esters) is convincingly explained as due to the non-alternating substances possessing long chains vertical to the end faces and the alternating series possessing tilted chains.

The chapter on sterols by W. Bergmann suffers from over-condensation in some sections since, although it is the longest in the book, more than fifty sterols are discussed, requiring about half the total space to list their formulæ and properties. This section is admirable, as is the author's classification scheme based on the optical rotation of the sterols and their derivatives. Excessive condensation occurs particularly in the sections dealing with analytical and preparative methods, which could, of course, easily be the subject of a whole chapter. Thus, the flat statement that "the most effective [micro] method [for the determination of sterols] appears to be the one developed by Schoenheimer & Sperry" does less than justice to a tremendous volume of literature, particularly since the one reference quoted is dated 1934, the later studies of Sperry himself also being ignored. There are other cases where later literature references might have been made—for example, in connexion with the biosynthesis of cholesterol, where by 1950 Little and Bloch had identified the origin of carbon atoms 10, 18, 19, 25, 26 and 27.

The section on the structure and properties of phosphatides, by P. Desnuelle, gives a curious impression of lecture style rather than prose style, probably because English is not the author's native language. Doubtless for the same reason, the argument at times is not readily followed. Thus, on p. 73 coconut and palm kernel are not mentioned in the table indicated by the text. The statement (p. 74) that all phosphatides involve an ester link between fatty acid and alcohol is incorrect (sphingomyelin), while Hilditch most certainly has *not* suggested random distribution of fatty acids in animal fats (p. 79). A serious error is the quoting of Klenk and Debuch (p. 80) as evidence of the occurrence of polyethylenic C_{20} and C_{22} acids in vegetable phosphatides—the title of Klenk and Debuch's paper is presumably responsible. This chapter suffers seriously throughout from inadequacy of discussion and literature references, and the subject is obviously too extensive for the space available.

R. T. Holman has provided, as one might expect, a most instructive account of the chromatography of fatty acids and related substances, including elution analysis, frontal analysis, displacement analysis and partition chromatography. The list might with advantage have been extended to include countercurrent distribution, which is so closely related to partition chromatography. The author emphasizes the empirical nature of most chromatographic techniques and points out the confusion which has resulted, since few experiments are comparable. He comments that chromatography has not yet reached the stage of a routine tool in the examination of lipids. Despite all these provisos, chromatographic techniques have effected some gratifying separations of lipids otherwise difficult to handle, and on a micro-scale.

H. J. Harwood has contributed a very detailed account of certain fatty-acid derivatives in which the carboxyl group is involved; but the sketchy section on derivatives involving the hydrocarbon chain might preferably have been omitted or incorporated, with more detail, into another (promised) chapter in a later volume. The main section of the chapter is well illustrated with equations, tables and figures; and industrial uses of many of the derivatives are listed, nitrogen derivatives occupying the greater part of the account.

J. A. Lovern

Dimensional Analysis

By Prof. H. E. Huntley. Pp. 158. (London: Macdonald and Co. (Publishers), Ltd., 1952.) 20*s*. net.

PROF. H. E. HUNTLEY has re-drafted the material of a lecture course for university physics students into book form to meet the obvious need for a text-book devoted entirely to the subject of dimensional analysis. The first part of the book is devoted to a discussion of the method in its simplest form with a number of worked examples. The second part attacks the problem of extending the number of fundamental quantities in order to remove some anomalies. For example, the dimensional formulæ for torque and work (both L^2MT^{-2} on the usual system) acquire a significant difference when the single dimension of length is replaced by three components along mutually perpendicular directions; torque becomes $L_XL_YMT^{-2}$ and work becomes $(L_X)^2MT^{-2}$. Similarly, certain advantages follow a distinction between mass as a quantity of matter and inertial mass—particularly in thermal problems. The consequences of these changes are discussed, and numerous examples of the use of the modified systems are given.

Unfortunately, the discussions are not as critical as could be desired, and the arguments and illustrations are not always entirely convincing. There are also one or two rather curious statements. For example, on p. 48 we read that the method of dimensions makes use of the principle ". . . that each term of a proper physics equation must be of the same dimensions in the fundamental quantities as every other term". One wonders what form of impropriety distinguishes those equations which obey the principle from those which do not.

However, although one would hesitate to recommend it to any but the most critical students, the defects seem to be rather in presentation than in basic material and, to the more mature physicist, it should present some stimulating ideas. It should certainly be read by all teachers of the subject.

C. A. TAYLOR

Algebraic Projective Geometry

By Prof. J. G. Semple and G. T. Kneebone. Pp. vii+404. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 35*s*. net.

THIS book provides honours students of mathematics with a rigorous axiomatic account of projective geometry, on an algebraic basis, assuming a knowledge of matrices and of such algebraic concepts as field, ring and group. The first chapter gives a brief account of the evolution of geometry from earth-measuring to a purely abstract system. The second chapter gives an elementary analytical treatment of projective geometry, linking it up with the usual co-ordinate geometry. These two chapters are merely introductory; the real subject of the book, the abstract axiomatic treatment, starts in Chapter 3, and is logically independent of all previous geometrical knowledge. Chapters 3–9 deal in this way with homography, conics, higher correspondences, apolarity, invariants, collineations and other transformations, with emphasis on Euclidean and affine specializations of projective geometry. In dealing with one and two dimensions it is found "necessary to proceed slowly and cautiously by small algebraic steps"; but when three dimensions are reached it is possible to "begin to detach ourselves from the details of algebra, making use once more of geometrical intuition, but this time less naïvely" (than in Chapter 2). The last seven chapters, perhaps the most interesting, deal not only with quadrics but also with some of the properties of the twisted cubic, cubic surfaces, line geometry and space of four and more dimensions. The book concludes with two basic algebraic theorems (one not proved here, as its proof is well known) and an index. There are numerous exercises in the text and at the end of every chapter except the first.

H. T. H. PIAGGIO

Mr. Tompkins Learns the Facts of Life

By Prof. George Gamow. Pp. xi+88+6 plates. (Cambridge: At the University Press, 1953.) 12*s*. 6*d*. net.

IN his elementary discussions on relativity, topology, philosophy and logic the late Rev. C. L. Dodgson takes the immortal Alice through a series of adventures which are so richly veiled in fantasy and humour that the meaning of the parable is not always apparent. Prof. George Gamow's wonderland is that of vitamins, chromosomes, cybernetics and energy changes in the life-cycle. His Alice is Cyril George Henry Tompkins, an American bank clerk "who was born at a comparatively late age, apparently in 1939". Very properly for Mr. Tompkins and his creator "the facts of life" have a broader and truer meaning than is usually given to them in Britain.

The present book is the last of a trilogy, the author having dealt in a similar manner with relativity and atomic physics. He is no less successful with his excursions into human biology. In a series of dream adventures, with the help of a variety of guides (including a masterly gene and a talkative electronic brain called the "Maniac"), Mr. Tompkins learns what answers genetics and biology can give to some of the questions about the nature of life. The author does not shrink from the difficulties of: What is life? How did it start? How do certain forms of atoms combined into complex molecules become living cells? He explains how a fundamental characteristic of life is negative entropy. He sums up, in terms that any ordinary thinking person can grasp, the present state of biological knowledge and the answers that it can give to some of the questions about ourselves and about life that have always bothered our minds.

W. L. SUMNER

Colloid Science

Edited by H. R. Kruyt. Vol. 1: Irreversible Systems. Pp. xx+389. (New York and Amsterdam: Elsevier Publishing Co., Inc.; London: Cleaver-Hume Press, Ltd., 1952.) 70*s*.

THIS book offers an expert account, although not a completely comprehensive one, of the properties of lyophobic colloids. The presentation is not elementary, and mathematics is not avoided, the text inclining generally to a theoretical rather than a practical emphasis. Apart from an introductory chapter by Prof. H. R. Kruyt and a contribution on the optical properties of colloidal solutions by Dr. G. H. Jonker, the book is entirely written by Prof. J. Th. G. Overbeek, of Utrecht. He gives a detailed treatment of the electrochemistry of the double layer and of electrokinetic phenomena and also discusses interaction between colloidal particles and the kinetics of flocculation. Questions of stability are dealt with, and there is a brief account of the rheology of lyophobic systems. This contribution from the Dutch school to the growing literature of colloid science will be welcomed by research workers and advanced students who are not afraid of making an effort as they read.

D. P. RILEY

FIFTY YEARS OF POWERED FLIGHT*

By Sir BEN LOCKSPEISER, K.C.B., F.R.S.

TO fly like the birds was for centuries man's dream and desire. The Wright brothers succeeded where so many others had failed because of the relentless scientific attack they made on the problem of flight. "The world is not fully aware of all the tedious, gruelling scientific laboratory work they had to do before flight was possible." They invented the wind tunnel to study and measure air forces, invented their own system of control and overcame difficulties of stability. They designed and built their own engine of some 20 horse-power, weighing not more than 240 lb.—itself a triumph of engineering at the time—and in the end designed and made a machine that would lift itself. Exactly fifty years ago this year, they flew this machine at Kitty Hawk in the United States and fulfilled the dream that man had cherished throughout the ages. It was a great achievement based on a rare combination of science, invention and engineering, and was one of the epoch-making events in history.

It is doubtful whether this machine ever climbed more than 10 ft. above the ground, for it had too much drag, too much weight and too little power to leave much margin for climb. But it was enough. A revolution in transport had been started. The main principles having been established and successfully demonstrated, progress was rapid. Six years after the flight of the Wright brothers, Blériot crossed the English Channel in forty minutes, and within sixteen years Alcock and Brown flew the Atlantic, for the first time, in less than seventeen hours. These three machines have changed the course of history.

Significance of Streamlined Design

Low drag involves something more than absence of unnecessary parts projecting in the air stream. It implies certain standards of excellence in shape and lines; streamlined, in fact, and the lines we speak of are lines of air flow which, could they be made visible, as they can be experimentally by means of smoke, would be seen, in a perfect shape, to bend smoothly and flow snugly around curved surfaces of the structure, leaving no turbulent wake. Any departure from the ideal aerodynamic shape promotes the breakaway of the air flow from the surface and the formation of large-scale eddies or turbulence. This churning up of the air is sheer waste, and the power to produce it makes an unnecessary call on the engine. A very large effort has been spent in learning how to avoid this and to design and produce low-drag wings. By careful design and construction and smoothness of surface we can achieve laminar flow over more than half the depth of the wing (or chord as it is called), when a transition occurs from the laminar to a turbulent type of flow which gives rise to an increase of drag. The best aircraft flying to-day carry wings capable of producing this type of flow, and we may be able, in the future, by the use of slots in the wing or porous wing surfaces, to control the air flow by suction and push the transition point farther back to produce a near approximation to laminar flow.

* Substance of an Evening Discourse at the Liverpool meeting of the British Association, delivered on Sept. 4.

For bodies moving in air at speeds below and not comparable to the speed of sound, the air behaves for all practical purposes as though it were incompressible, that is, its compressibility can be ignored. This does not hold as the speed of sound is approached. The velocity of sound in air at sea-level is about 760 m.p.h. and the effect of the compressibility begins to make itself sensibly felt above about 500 m.p.h. The effect of compressibility is to produce an increased drag rapidly growing with rising speed and reaching at the speed of sound a value many times greater than would be encountered if the air remained sensibly incompressible.

It is not immediately obvious why the speed of sound should play such a dominating and decisive part, and perhaps a few words from a purely physical aspect will not be out of place. At a speed well below the speed of sound or, as it is called, a low subsonic speed, the air conforms to a smooth flow pattern which extends forward of an aerofoil. The air ahead of the aerofoil is prepared in advance for its arrival, part being accelerated to flow over the upper surface and part over the lower surface. Clearly, the moving aerofoil possesses as it were a signalling system to warn the air ahead of its approach and allow it to take full advantage of its shape to slip through. What I have called the signalling system is based on changes of air pressure. The flow pattern is also a pressure pattern, for wherever the flow lines are curved a change of pressure occurs, giving rise to the lift and drag of the aerofoil. It is clear from the flow pattern that there is a pressure change ahead of the aerofoil, and this is the physical basis of the signal. Pressure changes in any medium are, however, not transmitted instantaneously, but with a particular velocity, dependent on the medium, and this velocity for pressure changes of the order of magnitude under consideration is the speed of sound in air. It follows, therefore, that if the aerofoil is travelling at or above the speed of sound (that is, at sonic or supersonic velocity) it is robbed of any means of signalling ahead. The air can no longer be prepared for its arrival. The aerofoil can no longer slip smoothly through the air: it now meets it, inevitably, head on, producing a shock wave which is the source of the largely increased drag.

This is fundamental, for it is impossible to avoid the formation of shock waves whenever the velocity of the air relative to the surface exceeds the local speed of sound. This is bound to happen at a forward speed appreciably below the speed of sound in the atmosphere, because the air is accelerated in its flow over a curved body such as a wing. The shock wave occurs at the downstream end of the local region of supersonic flow, and behind it the speed is subsonic. The position of the shock wave depends on the shape of the wing section and its incidence, as well as on the forward speed. [A film, taken in a wind tunnel at the National Physical Laboratory, illustrated the formation of shock waves on a conventional symmetrical aerofoil as the speed increased from subsonic to supersonic, and showed the movement of the first shock wave back towards the trailing edge as the speed increases at constant incidence.] When the shock wave moves back, the low pressure in the

region of supersonic flow ahead of it extends over a larger fraction of the aerofoil surface, and there is therefore a movement of the centre of pressure with speed and incidence. This causes a considerable change in the stability of the aircraft. The occurrence of shock waves may also cause conventional control surfaces to become relatively ineffective, and this has led to the adoption of all-moving tail planes as in the North American "Sabre". At supersonic forward speeds a bow wave is formed, and the flow again becomes stable with no serious changes in the position of the centre of pressure as the speed or incidence is varied.

Matters are complicated by the fact that the speed of sound does not remain constant but, because of the fall in temperature, decreases with altitude. It falls continuously from 760 m.p.h. at sea-level until the stratosphere is reached, where the speed is 660 m.p.h. An aircraft flying at, say, 600 m.p.h. in the stratosphere is much closer to the speed of sound than when flying at this speed at sea-level. The significant and determining factor in compressibility phenomena is thus not the actual speed of the aircraft itself but the ratio of its speed to the velocity of sound at the altitude at which the aircraft is flying. It is usual, therefore, in dealing with the performance of high-speed aircraft to speak of the Mach number, that is, the ratio of the forward velocity to the local velocity of sound.

It is clear that the onset of shock wave conditions at high subsonic speeds can be delayed by reducing the acceleration produced by curvature, and high-speed flight therefore calls for slim wings, nacelles and bodies. These increase the speed at which shock waves first appear, called the critical speed, which can be raised still further by the use of swept-back wings, the effect of which is to reduce the effective thickness-to-chord ratio of the wing in the direction of flight, and hence to reduce the curvature of the wing surface. The effect of sweep-back in delaying the rise of drag is illustrated in Fig. 1, which compares the drag curves of two hypothetical modern aeroplanes of equal wing-areas—one square-winged and the other swept back 45°. The diagram illustrates also that the advantage of sweep-back disappears at high Mach numbers. A typical modern fighter having swept-back wing and tail surfaces is the Hawker "Hunter".

High sweep-back, however, creates difficulties of its own. The twisting of the wing under load causes loss of lift at the wing tips, which in the swept-back wing are well behind the centre of gravity of the aircraft, giving rise to problems in pitch control. The degree of sweep-back required is related to the curvature of the wing surface which, diminishing progressively from the wing root to the tip, leads ideally to a crescent shape for a swept-back wing, thereby easing the control problem. This principle is embodied in the Handley Page "Victor" jet bomber.

The swept-back wing has been taken a step further in the so-called "Delta" wing aircraft, which embodies a swept-back leading edge and an unswept trailing edge, with the chord falling uniformly until it is zero at the tips. The main advantages of the "Delta" wing are its increased stiffness and stowage capacity: the former diminishes the wing tip problem already referred to and helps to avoid flutter. The large centre-section thickness which becomes possible with a long centre-section chord enables jet engines to be completely buried in the wing, and space is also available for more fuel and payload. The latest "Delta" wing aircraft flying is the Avro "Vulcan" jet bomber.

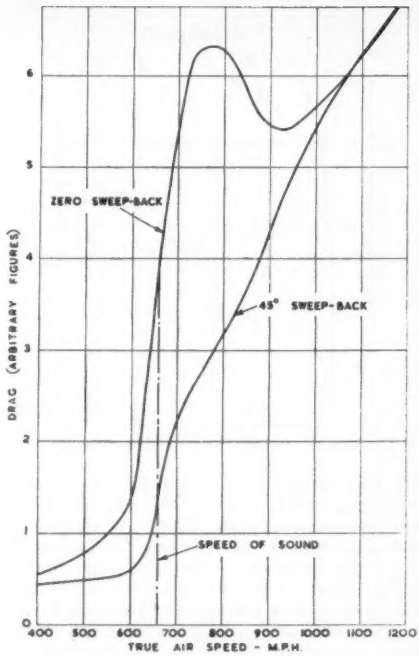

Fig. 1. Effect of sweep-back on drag at 40,000 ft. (equal wing areas)

Propeller versus Jet for Motive Power

We have, therefore, means at our disposal for reducing the drag of aircraft both up to and well beyond the speed of sound; but the drag at these high speeds is, however, formidable enough, and the thrust to overcome it has only become possible by the introduction of the gas turbine and propulsion by reaction from a very high-speed jet of gas. Propellers, like aircraft wings, are subject to compressibility drag effects, and the combination of forward and rotational velocities introduces increasing drag conditions over a considerable portion of the blade area after about 400 m.p.h. Up to this point, from comparatively low speeds, the propeller is a very efficient means of propulsion, efficiencies of about 85 per cent being not uncommon; but at higher speeds compressibility drag becomes of increasing significance and the efficiency drops sharply. This is shown in Fig. 2, which contrasts this behaviour with the rise of efficiency of the jet as a means of propulsion, and explains why the use of a jet is so necessary for high-speed propulsion.

On this showing, the propeller ought to hold its own with the jet up to speeds of at least 500 m.p.h. and, theoretically, even beyond this figure, by the application to propellers of the principles of wing design for reducing compressibility effects already referred to. But, in practice, propulsion by jet is ahead of the propeller at lower speeds than this, because of other considerations. The elimination of the propeller eliminates also the disturbance of the air flow over the wing besides saving the weight and drag of the propeller. The turbo-jet engine is much

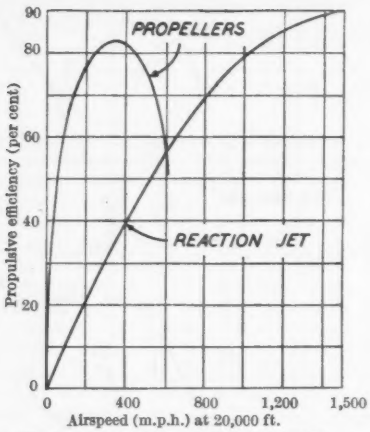

Fig. 2. Comparative propulsive efficiencies

lighter and occupies less space than a corresponding piston engine, offset though this is by the jet engine's higher fuel consumption. Range, of course, plays a determining part in the balance of these factors, but it is not the only one. The turbo-jet, particularly with axial flow compressor, can be built with a much smaller frontal area per unit of thrust than any other type of air-consuming engine, and it can be made to develop thrusts far in excess of anything hitherto obtainable. The superior efficiency of the jet over the propeller as a means of propulsion at high speeds, the absence of any propeller slipstream to increase drag, the comparatively small engine frontal area and the very high thrusts obtainable from these jets are the main reasons why the turbo-jet has swept the field in the high-speed range. Nor should we overlook the fact that the gas turbine is not fussy about the nature of its fuel. Aero piston engines demand expensively manufactured fuels of high octane number, whereas the aero gas turbine will burn either cheap motor spirit or paraffin. Paraffin is preferred because it gives less trouble with vapour-locking at altitude, and because its calorific value per unit volume is slightly higher.

Before the introduction of the gas turbine, the piston engine had already been developed to a high degree of excellence both in performance and reliability. Concurrently, its weight per horse-power had been reduced from the Wright brothers' 12 lb. per b.h.p. to just over 1 lb. per b.h.p. to-day; and in co-operation with the fuel technologists its specific fuel consumption (that is, the fuel consumed per b.h.p. hour) has been brought down from about 0·6 to 0·42 lb./b.h.p./hour. The aircraft diesel engine was not put into production in Britain, but in Germany the ingenious Junkers Jumo 205 opposed-piston two-stroke diesel engine had given consumption figures as low as 0·36 lb./b.h.p./hour in service. Unfortunately, it was very heavy for its power, weighing 1·8 lb. per b.h.p.

As I have already indicated, the gas turbine introduced by Whittle has revolutionized aircraft propulsion by making possible speeds which would be unattainable with a piston engine and propeller. The gas turbine can be used in two ways. First, all the power developed by the turbine is used to drive the compressor, and the exhaust is discharged as a high-speed, high-temperature jet of gas; this is the turbo-jet, of which the Rolls Royce "Avón" is a typical example. Alternatively, part of the power developed by a more powerful turbine—commonly about one-third—can be used to drive a propeller; this is the turbo-propeller engine. Each type of engine has its place in the field of aircraft propulsion.

The propeller turbine, intermediate between the straight jet and the piston engine and propeller, is heavier than the straight jet, but makes much more economical use of the same kind of cheap fuel. It can be quieter than any other kind of aircraft engine yet produced, and it is almost vibrationless. The Armstrong Siddeley "Mamba" is an example of this type of engine.

Fuel Consumption

Although we hear much about supersonic flight, which, of course, has been achieved, it is being more and more realized, if only because of the very high fuel consumption demanded by such high speeds, that it will be a very big step from our present subsonic civil airliners to the supersonic versions. When operating at extreme range, the "Comet I" takes off with 22 tons of fuel for 21 tons of aeroplane and four tons of crew and payload. Increasing attention is therefore being paid to the problem of greatly improving overall propulsive efficiency at high subsonic speeds. This can be done by the ducted fan or by-pass engine, which increases the mass flow of air through the engine and reduces the mean jet velocity. Such engines will probably reduce the fuel consumption by 25 per cent as compared with a straight jet. The Rolls Royce "Conway" is an engine of this type. It is a likely power plant for the De Havilland "Comet's" successor.

The present emphasis on jets does not mean that the piston engine can be entirely forgotten. In small sizes, the gas turbine cannot compete with it in first cost or economy of operation. In large sizes, provided one does not want to fly much faster than 300 m.p.h., the compound engine (part piston, part turbine) can beat all the others for very long-range operation. In the United States, compound engines have been produced by addition of multiple-exhaust turbines geared to the engine crankshaft. The Wright "Turbo-Cyclone" is an example of this: it has a cruising specific fuel consumption of 0·39 lb./hr./b.h.p. and has been chosen to power the latest American long-range civil aircraft, such as the "Super-Constellation". In Great Britain the compound engine has, in my opinion, been tackled more fundamentally, and we now have the Napier "Nomad", which uses a two-stroke diesel engine with a high-pressure exhaust turbine. This engine has achieved the lowest specific fuel consumption ever recorded for an aircraft engine (0·33 lb./hr./b.h.p.) and weighs only 1·2 lb. per b.h.p.

Modern Alloys in Aircraft Design

The metallurgist has played a leading part in the great advances made in both aircraft and engines. When the Wright brothers flew, aluminium was little more than a scientific curiosity, a low-density weak metal of about 5 tons per sq. in. tensile strength. Modern aircraft aluminium alloys have a tensile strength as high as 40 tons per sq. in. with a density one-third that of steel, and the proof stresses of aluminium alloys have been almost doubled since the time of the First World War—an outstanding achievement providing a striking example of progress made under the spur of necessity.

The development of light alloys which could be rolled into sheet of high strength coincided with

important advances in structural science and led to the introduction of the cantilever monoplane, which created a major revolution in aircraft engineering. The main structural change was the introduction of stressed skin or monocoque construction. This innovation killed two birds with one stone. It replaced fabric with a more robust material, more capable of resisting deformation and change of aerodynamic shape, and it enabled the surface covering to contribute very substantially to the strength of the structure as a whole. It made the most efficient use of material by placing it as near as possible to the outside surface. The skin now provides nearly all the torsional stiffness, and it also contributes to the bending strength of the wing, thus enabling a reduction in the weight of the main spars to be made. The tail surfaces have developed on similar lines, while the fuselage early lent itself to monocoque construction.

The recently developed magnesium alloys, especially those containing zinc and zirconium, have proved of great value in light-weight castings, such as those for the reduction gear casings of aircraft gas turbines, for they have a strength/weight ratio nearly 20 per cent greater than that of the best aluminium alloys. Magnesium alloys are also becoming available as forgings, extrusions and rolled sheet with very promising engineering properties. High specific strength is not their only virtue: they can be machined faster and more easily than any other engineering material, and they have completely displaced aluminium alloys in aircraft wheels. Magnesium alloys now account for about one-third of all light-alloy castings supplied to the aircraft and engine industries, and the proportion is growing.

Light alloys based on aluminium and magnesium suffer, however, a rapid loss of strength with rise of temperature. This has for long been a serious drawback in piston engines, where the piston temperature has limited cylinder diameter and power output. In the gas turbine, compression raises the temperature of air leaving a compressor with a compression ratio of 6 : 1 to well over 200° C., and copper-bearing aluminium alloy blades are now giving way to those of titanium alloys containing chromium and iron, the strength characteristics of which with temperature, compared with those of aluminium alloys and sintered aluminium powder, are shown in Fig. 3. Titanium alloys which have so far been investigated are twice as strong as aluminium alloys for one and a half times the weight, and further improvements in strength/weight ratio may be achieved.

Alloys for aircraft, however, require to be not only strong for their weight but stiff also, and, in this respect, present-day titanium alloys are, on a comparative basis, inferior to both aluminium alloys and steel by about 10 per cent. This matters a great deal; for the development of the modern aeroplane, particularly as regards speed, has introduced a new criterion in design, namely, structural stiffness, which is now a consideration comparable in importance with strength. A reasonable degree of stiffness is essential on practical engineering grounds, but the main concern is with flutter. This is a complicated aeroelastic phenomenon in which, at a particular speed, dependent on the characteristics of the structure, oscillations occur of progressively increasing amplitude, rapidly ending in structural disintegration. Flutter is the skeleton in the cupboard of all high-speed aircraft designers, for all structures are liable to flutter in a wind in certain circumstances,

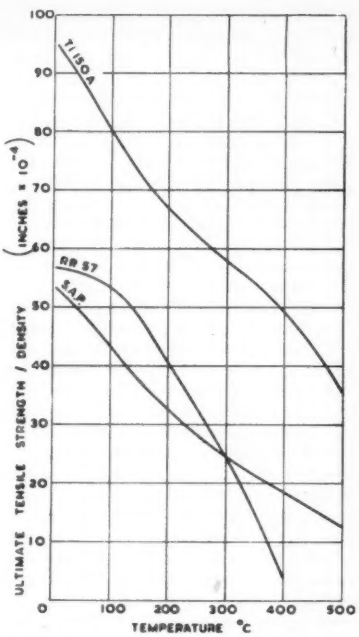

Fig. 3. Variations of ultimate tensile strength with temperature for various materials for compressor blades

and the higher the speed the greater the risk. The best a designer can do is to ensure, so far as he can, that the flutter speed is well above the highest practical flying speed. Various measures can be taken to this end, but high stiffness both in bending and twisting is the principal safeguard.

In addition to strength and stiffness at the minimum cost in weight, a third criterion—fatigue—has to be taken seriously into account by the designer in his choice of materials, and this is becoming more and more a matter for anxiety as new alloys of higher static tensile strength come into use. Aircraft have to be designed to deal with not only their normal static loadings but also additional repeated loadings, due mainly to gusts encountered in the atmosphere, which vary greatly according to time and intensity. In the structural laboratory, complete wings are subjected to fluctuating loads broadly representative of a flight in bumpy weather until failure occurs.

Problems of Take-off and Landing

As a consequence of these advances in the several fields of science, technology and design, and with a recognition of the vital part played by the skill of pilots, aircraft speeds have increased steadily with the years, and at an increasing rate, from a maximum speed of 70 m.p.h. in 1910 to more than 700 m.p.h. in 1953. Fighter aircraft are, of course, built primarily for speed, but transport aircraft and civil airliners have to compromise on speed to fulfil the requirements of range and economy. Their maximum speed is therefore lower and their cruising speed, at which fuel is used more economically, lower still. Nevertheless, it is of interest to note that the cruising speed of jet civil aircraft is much closer to their maximum speed than is the case with propeller-driven aircraft.

High speed, however, carries certain consequences, among which is a high rate of fuel consumption which cuts into payload. We can get anywhere in the habitable world in hops of about 2,000 miles or so, and, as we pay for speed by fuel consumption, a fast aircraft at the beginning of a 2,000-mile flight is virtually a flying tanker. About half its all-up-weight is accounted for by fuel. This is not the only price we pay for speed, for higher flying speeds have involved higher landing and take-off speeds, and fast long-range aircraft are not only inevitably heavy but also demand long and expensive runways. Aircraft *weight* determines the thickness of concrete for a given sub-grade, and take-off speed, for a given acceleration, the length of runway. At the London Airport the longest runway is rather less than two miles, and concrete a foot thick is used on a stable gravel base. The airport covers nearly 3,000 acres and its estimated cost on completion is of the order of £21 million. If aircraft are to become larger and heavier, as is likely, the provision of concrete runways presents very serious economic problems.

The flying boat offers a possible means of escape. Until comparatively recently, the performance of the flying boat was inferior to that of the corresponding land plane, but several advances have now made it a serious competitor. The flying boat always had the advantage of being able to dispense with an undercarriage, which, in a modern large aeroplane, may account for 6 per cent of the total structure weight; but this was for a long time more than offset by the excessive size and weight of a hull which had to carry the propellers high above the water to keep them clear of the spray. Jet propulsion has changed all this, and a smaller hull, combined with improvements which can now be made in its aerodynamic design, may well tip the balance in favour of a flying boat for all-up weights of 50 tons and above.

Finally, we have in recent years come back to where Leonardo da Vinci began, and devoted serious attention to the rotary wing aircraft. It can never match the fixed-wing aeroplane for speed, but it can land on and take off from a small space, rise and descend vertically, and fly horizontally at a speed which gives it an advantage in door-to-door times for journeys of a few hundred miles.

THE MELTING OF IRON AT HIGH PRESSURES

By Prof. F. E. SIMON, C.B.E., F.R.S.
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THE knowledge of the dependence of the melting pressure of iron on temperature would be of importance to geophysics. So far, however, no information about the melting of iron at high pressures exists and there does not seem to be much chance, in the foreseeable future, of obtaining it directly under conditions approaching those in the interior of the earth. Therefore, when I derived about twenty-five years ago a semi-empirical formula[1] connecting the melting parameters with the internal pressure, I applied it tentatively to the case of iron. At that time, however, the range of validity of the formula had not been widely explored and I therefore restricted myself to a few qualitative remarks[2].

In the meantime, the formula:

$$p/\alpha = (T/T_0)^c - 1, \qquad (1)$$

where α is a constant related to the internal pressure, T_0 is the normal melting temperature and c is a numerical constant, has successfully served as a guide to our experiments which have been pushed, in the case of the low melting point substances, to very high *relative* temperatures[3]; helium, for example, has been solidified at temperatures more than ten times the critical temperature. Also, the formula has recently been given a theoretical foundation[4] which, although not accounting for all the details, confirms the general form and the fact that it is the internal pressure of the condensed phase which is the determining quantity. Furthermore, recent experiments have at last provided reliable data for the heat of fusion and the volume change of iron at the normal melting point, whereas not long ago even the sign of the volume change was in doubt. These values make it possible to derive the initial slope of the melting curve and in this way to eliminate one of our constants. The time, therefore, seems appropriate to try to predict the melting pressures of iron at high temperatures, particularly in view of the increased interest of geophysicists, some of whom now assume that the core of the earth consists of solid iron surrounded by the liquid phase (see, for example, Bullen[5], Birch[6]).

The majority of substances for which the melting curves have been investigated experimentally—mainly by Bridgman[7]—are those held together by van der Waals' forces. For all these substances the constant c turned out to be nearly the same and of the order of 1·5–2. Our knowledge of the melting curves of metals is unfortunately much more restricted, practically to that of the alkalis, and here c was found to be much higher, as will presently be discussed.

Again, for the van der Waals substances the value of α was found[8] to be very nearly equal to λ_i/V (where λ_i is the energy difference between gas and liquid, and V is the volume of liquid), a value which can be derived by applying the thermodynamic expression for the internal pressure $\left(\frac{\partial U}{\partial V}\right)_T$ to the van der Waals equation. In the case of the metals, the agreement was poor, as could only be expected owing to the completely different type of binding forces; consequently we cannot calculate α for iron in this way.

In choosing our values of α and c, we can make use of the fact that the initial slope of the curve[2] is given according to (1) by:

$$\frac{dp}{dT} = \frac{c \cdot \alpha}{T_0}.$$

On the other hand:

$$\frac{dp}{dT} = \frac{r}{T\,\Delta V} \quad (r = \text{heat of fusion}),$$

and thus $c \cdot \alpha = r/\Delta V$.

Recently, Awbery[9] in a careful survey has come to the conclusion that the heat of fusion is 64–65 cal./gm., and I am grateful to Dr. R. W. Powell for informing me that recent unpublished experiments at the National Physical Laboratory confirm this value. Also new experiments of Stott and Rendall[10], again at the National Physical Laboratory, have shown that

the volume of iron increases on melting by $3 \pm 0{\cdot}5$ per cent. From these values we can derive

$$\frac{dp}{dT_{(T=T_s)}} = 330 \text{ atm./degree}$$

or,

$$c \times \alpha = 600{,}000 \text{ atm.} \quad (2)$$

In trying to select the best values of c and α we have given in the first two columns of Table 1 the values which follow from Bridgman's[7] data for the melting curves of the alkali metals. Lithium has been omitted, as only values for a rather impure sample are available[11].

Table 1

	c	α (atm.)	$(\partial U/\partial V)_T$ atm.	$\alpha \Big/ \left(\frac{\partial U}{\partial V}\right)_T$
Na	3·8	11,000	5,750	1·9
K	4·5	4,000	2,850	1·4
R	4·2	3,400	2,400	1·4
Cs	4·8	2,400	1,600	1·5
Average	4·5			$1{\cdot}5_8$

One way to proceed would be simply to attribute a similar value of c to iron, namely, 4·5, which in turn would imply $\alpha = 133{,}300$ atm. On the other hand, too little is yet known on how c depends on the constitution of the substance, and it is desirable to have an independent way of calculating one of the constants. In the third column of Table 1 we have given the values of the internal pressure, calculated as $(\partial U/\partial V)_T$. The most convenient way of evaluating this for the normal melting temperature ($p = 0$) is to write it in the form[12]:

$$\left(\frac{\partial U}{\partial V}\right)_T = \frac{\gamma C_v T}{V} \quad (\gamma = \text{Grueneisen constant}). \quad (3)$$

We obtain the right order of magnitude, and column 4 shows that the ratio of α to $(\partial U/\partial V)_T$ averages $1{\cdot}5_8$. If we now calculate the internal pressure for iron according to equation (3), a value of 110,000 atm. is found at the melting point ($T = 1{,}805°$ K.). Assuming the same ratio as with the alkali metals, we obtain $\alpha = 170{,}000$ atm. and therefore $c = 3{\cdot}5$. We choose as the most probable set of values one intermediate between the two, namely, $c = 4$ and $\alpha = 150{,}000$ atm.:

$$p_{\text{atm.}} = 150{,}000\,[(T/1{,}805)^4 - 1]. \quad (4)$$

For very high pressures equation (4) reduces to:

$$p_{\text{atm.}} = 1{\cdot}4\,(T/100)^4;$$

at 1,000,000 atm., for example, this involves an error in T of less than 4 per cent. (*Note added in proof.* I understand from Sir Edward Bullard that he also has applied equation (1) to the melting curve of iron and arrives at similar results. His calculations are to be published early next year by the Chicago University Press in Chapter 3 of Volume 2 of "The Solar System", edited by G. P. Kuiper.)

The validity of equation (4) rests on a few assumptions. The first is that the body-centred cubic δ modification of iron which is stable in the region of the normal melting point continues to be so at higher temperatures. This should be a reasonable assumption; but even if there is a transition to another modification, the only result would probably be a slight decrease in the slope of the melting curve. The second qualification is that no critical point between the solid and fluid phase intervenes: this seems to be justified by the fact that we have solidified a number of substances at very much higher *relative* temperatures[3,13]. Finally, equation (4) would probably cease to be valid if a change in the configuration of the electrons in the outer shell of the iron atom should occur at very high pressures.

Table 2 gives the melting temperatures calculated from equation (4) for a number of pressures, while, to indicate possible limits of error, values calculated with $c = 3{\cdot}5$, $\alpha = 170{,}000$ atm. as well as $c = 4{\cdot}5$, $\alpha = 133{,}000$ atm. have been included.

Table 2

	$c = 3{\cdot}5$; $\alpha =$ 170,000 atm.	$c = 4$; $\alpha =$ 150,000 atm.	$c = 4{\cdot}5$; $\alpha =$ 133,000 atm.
p (10^4 atm.)	T (°K.)	T (°K.)	T (°K.)
0·1	2,060	**2.050**	2,040
0·2	2,250	**2 230**	2,210
0·5	2,670	**2 600**	2,550
1·0	3,130	**3.000**	2,900
1·5	3,460	**3 290**	3,150
2·0	3,730	**3 510**	3,340
2·5	3,970	**3.700**	3,500
3·0	4,170	**3 860**	3,640
3·5	4,340	**4 010**	3,760
4·0	4,500	**4 140**	3,870

If the core of the earth consisted of *pure* iron, the equilibrium temperature at the discontinuity at 5,000 km. depth would follow from equation (4) as 3,900° K.; at the centre of the earth the temperature would have to exceed 4,000° K. in order to obtain a core of pure iron in the liquid state (both temperatures are subject to the probable error indicated in the table).

The limitations of our extrapolation need scarcely be emphasized. The best way of arriving at a more secure prediction would be to measure the melting pressures up to values which permit the determination of the curvature of the melting curve. This would imply measurements up to at least 100° above the normal melting temperature corresponding to pressures of about 40,000 atm.; it is evident that no such experiments can be expected in the near future. The second best way for narrowing down the limits of error seems to lie in a better theoretical understanding of the interrelation of the constants of formula (1) and the properties of the single phases. Until this is achieved, the values given above seem to me to constitute the best possible estimate.

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THE R.A.F. MOBILE HEARING RESEARCH UNIT

By Air Vice-Marshal E. D. D. DICKSON, C.B., C.B.E., and L. J. WHEELER

Acoustics Laboratory, Department of Otorhinolaryngology, Central Medical Establishment, Royal Air Force

INTENSE noise is a by-product of the mechanical age in which we live, and prolonged exposure to it is liable to affect hearing adversely. The effect will vary with the individual according to his auditory susceptibility. In the early stages of acoustic trauma the hearing mechanism becomes temporarily fatigued but will usually recover; ultimately, what was once a temporary fatigue is liable to become permanent, with definite damage to the hearing mechanism, and thus deafness ensues.

The possibility that the noise of modern aircraft (which includes jets) may affect the hearing of aircrews has been investigated in the laboratory, but no data are available of the effect on aircrews flying under operational conditions. We have planned, developed and had constructed a mobile otological research unit—the first of its kind in Great Britain—which will enable us to test the hearing of aircrews within a few minutes of their stepping from the aircraft.

Hitherto, the post-flight hearing was tested as soon as possible after landing. This was carried out by audiometry in any room conveniently near the 'tarmac'—at the quickest ten to fifteen minutes after landing. As recovery from the effects of noise sets in very soon after the noise has ceased, this time-lag between landing and testing has distorted any results previously obtained of the immediate post-flight conditions. Now it will be possible to drive up to the aircraft as it rolls to a standstill and start hearing tests immediately; the test conditions will also be standardized from the point of view of background noise in the testing room. The results thus obtained will be a more accurate estimation of the effects of flight.

In brief, the Research Unit (Fig. 1) is mounted on a 7-ton Bedford general-service chassis and consists of two compartments, namely, a triple-walled sound-proof cell and an ante-room. In the ante-room the subjects' ears can be clinically examined, while in the sound-proof room hearing tests by audiometry can be carried out. The latter room is comparable to that in use at the Central Medical Establishment, Royal Air Force.

Construction Details

A plan view of the unit, excluding the vehicle cab, is shown in Fig. 1. The major part of the construction consists of oak planks which are tongued and grooved together. The outer walls are diagonally braced with steel bars across their inner surface to give added rigidity. To give some absorption of internally generated noises, the ceilings, all walls and doors of both compartments have a surface of perforated 'hardboard' backed by 'fibreglass', and both floors are covered with 'Airtread' rubber flooring.

The inner room—the test room—has a three-thickness assembly for walls, floor and ceiling. The spaces between the walls and between the ceilings are filled with hair felt; those between the floors with fibreglass quilting. At no point does this inner cell come into direct mechanical contact with any other part of the structure. Double doors give access to it from the ante-room.

The subject when under test can be seen through the sealed plate-glass double window in the walls common to the ante-room.

Beneath the window in the test room is a shelf on which is the Morse key by which the subject signals to the tester in the ante-room.

The ante-room has, except for the dividing walls between it and the inner cell, only one wall thickness: but the floor is raised by deep joists and extra thicknesses of quilted fibreglass to the level of that of the inner cell.

The ante-room contains the audiometer, all clinical instruments and the apparatus required to check and maintain the calibration of the audiometer. The clinical instruments are carried in drawers beneath the glass-topped shelf and the calibration apparatus in a lower cupboard beneath the drawers.

On the wall away from the inner cell a Chiron bull's-eye examination lamp is fitted. Above that is a ventilation fan of the extractor type; it can be covered when testing is in progress in order to present a uniform wall surface.

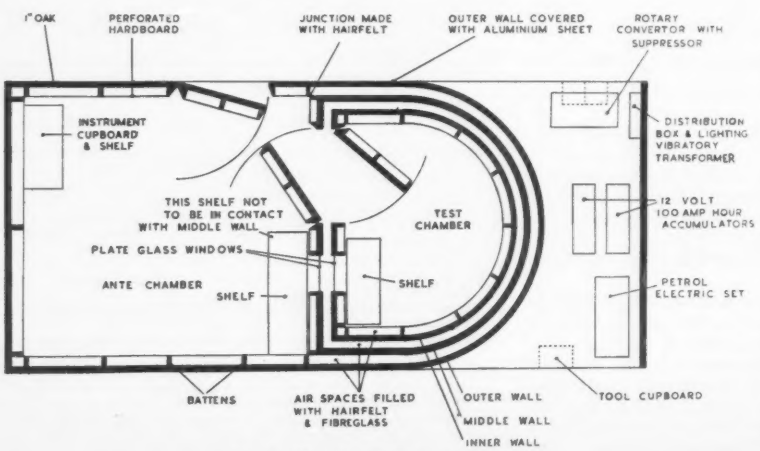


Fig. 1. Plan view of the hearing test unit

Equipment

The audiometer used is of the pure tone type and has been designed, constructed and calibrated in the Acoustics Laboratory of the R.A.F. Central Medical Establishment. The calibration and performance fulfil the requirements of the latest specification for pure tone audiometers.

Since the vehicle is entirely self-contained, it is independent of external power supplies. The power for all the equipment is provided by two 12-V. aircraft starter batteries mounted on a platform forward of the test room. These have three uses: (1)

to drive a rotary convertor to produce 230 V. A.C. for the operation of the audiometer, its calibrator and the Chiron lamp; additional outlet sockets are provided for a soldering iron or other equipment; (2) to drive a vibratory transformer to produce 90 V. A.C. for the six 15-W. fluorescent lights—four in the ante-chamber and two in the test chamber; (3) direct, for the operation of the 24-V. D.C. extractor fan.

A 360-W. petrol-driven charging set for the accumulators is also installed. This charging set, the rotary transformer, interference suppressors and the vibratory transformer are all carried with the accumulators on the platform between the chamber itself and the vehicle cab. All are fitted with weather-proof metal covers, while that of the rotary convertor is also lined with sound-absorbent material.

Beneath this platform distilled water for the accumulators, a test meter and all small tools are carried in two rubber-lined weather-proof lockers.

OBITUARIES

Dr. B. Mouat Jones

THE announcement of the death of Dr. B. Mouat Jones on September 11 at the age of seventy came as a great shock to all who knew him. Since his retirement in 1948 he had led a most active life, and right up to the last he seemed to be in better physical condition than most men ten years his junior.

Educated at Dulwich and at Balliol College, Oxford, where in 1905 he took a first-class honours degree in chemistry, mineralogy and crystallography, Mouat Jones followed a brief appointment at the Imperial Institute by a seven-year sojourn in India as professor of chemistry at Government College, Lahore. In 1913 he returned to England to become assistant professor of chemistry at the Imperial College of Science and Technology; but the outbreak of war put an end to this phase of his career and he enlisted at once as a private in the London Scottish. It was not long, however, before Prof. W. Watson selected him to become his assistant director at the Central Laboratory G.H.Q., in France, there to participate in countering the German onslaught of gas warfare. In this, where speed was of paramount importance, Mouat Jones was remarkably successful; and worthy of special mention in this connexion were his devising of methods of protection from phosgene gas and his rapid identification of what by a curious accident became known as 'mustard' gas. By the end of the War he was the director in charge of the laboratory with the rank of lieutenant-colonel, and with the D.S.O. and three mentions in dispatches to his credit.

Returning to civilian life, he held for a short period the chair of chemistry at Aberystwyth; but in 1920 he was elected principal of the Manchester College of Technology, where he spent the next seventeen years of his life. The outstanding success with which he held this office can only be properly appreciated by those thoroughly acquainted with the nature of his task, and with the form of the concordat between the University and the City which established the College as the Faculty of Technology in the University of Manchester. It is perhaps only necessary to say here that the success with which harmonious working relationships were established among all those concerned was due in a very large measure to the impact and influence of those personal qualities with which Mouat Jones was so exceptionally gifted: high moral courage and integrity, firmness of purpose, human understanding and a strong sense of humour, and perhaps, above all, an unshakeable faith in the future of technology as a vital part of the university system of Great Britain.

Being by nature modest and retiring, he accepted with some trepidation the invitation in 1938 to succeed Sir James Baillie as vice-chancellor of the University of Leeds; but there again the same personal qualities carried him through an exacting ten years term of office with conspicuous success. Not only had he to guide the destiny of the University through the difficult war-time years, but also by wise judgment and strict impartiality to keep the University on an even keel during the even more difficult years of rapid expansion which followed.

In addition to the formal duties of his several offices, and before and after his retirement, Mouat Jones served the State, the Commonwealth and his fellow-men in a great variety of ways—too many to detail in this short notice; but by all those who had the good fortune to know him he will be remembered not so much by what he did as for what he was. He had his enemies, as nearly all men must who hold high office; but his friends and admirers were legion. Though not naturally gregarious, he was one of the most approachable of men and won the high regard and warm affection of an astonishingly large number of those of all degrees who in one way or another came under the influence of his personality. By those who met him casually at public dinners and similar functions, he will be long remembered as one of the wittiest and most accomplished of public speakers; but to his one-time colleagues and associates and also to his innumerable old students now spread over the four quarters of the globe, his passing is that of a trusted and irreplaceable friend. W. E. MORTON

The Duke of Bedford

THE twelfth Duke of Bedford, whose death at the age of sixty-four has occurred, had other activities than those connected with Evangelical Christianity, social work, monetary reform and the kindred subjects by which he was best known to the public. His interest in zoology was of the keenest. His father and mother left at Woburn a fine collection of deer, bison, waterfowl, etc., and this collection he not only maintained but also enhanced. He knew his animals intimately, as was apparent when he took me around the park in August last. We paused to look at a number of red deer. He pointed out the different stags and told me their ages and details of their careers.

The unique herd of Père David's deer were his special delight. This large donkey-like species, which is exterminated in its native China, is represented only by the three or four hundred animals at Woburn and a few the Duke sent elsewhere. There are no others in the world. It is thanks to the Duke of Bedford it survives. He was also proud of his European bison and showed me with delight the new bull he had obtained with much trouble from Sweden. Seeing how precarious is the position of this species on the Continent, zoologists must again be grateful for the sanctuary afforded the individuals at Woburn.

The Duke of Bedford was also an ornithologist, having made a life study of the parrots and allied birds. Prior to the War he had a remarkable collection of such birds; but war-time difficulties led

to its reduction. However, when war ceased he again got together many rare and little-known species. His book on "Parrots and Parrot-like Birds in Aviculture" is an authoritative work.

One of his special joys of recent years was to watch his "liberty budgerigars". It was indeed a lovely sight to see a number of these butterfly-like birds flying free.

Not only was the Duke of Bedford a practical zoologist and ornithologist but also nothing gave him more pleasure than to assist others with like interests. He was ever ready to help, being kindness itself to many a young naturalist.

Frances Pitt

We regret to announce the following deaths:

Prof. C. Białobrzeski, formerly professor of theoretical physics in the University of Warsaw, aged seventy-five.

Mr. P. E. Negretti, chairman and managing director of Negretti and Zambra, Ltd., on September 20, aged seventy.

Prof. W. M. Roberts, O.B.E., lately professor of mathematics in the Royal Military Academy, Woolwich, on October 16.

Dr. L. F. Richardson, F.R.S., formerly principal of Paisley Technical College, on September 30, aged seventy-two.

NEWS and VIEWS

Geology at the University College of North Staffordshire: Prof. F. Wolverson Cope

The University College of North Staffordshire, at Keele, was opened in 1950 with thirteen professors. The academic staff now numbers more than eighty, and two new chairs—of classics and geology—have recently been created. Each of these posts goes to the reader in the subject, and the new professor of geology is Dr. F. Wolverson Cope. Educated at King's School, Macclesfield, and the University of Manchester, Dr. Cope served in H.M. Geological Survey from 1934 until 1950. He is a field geologist primarily, his main work having been on the stratigraphy and palæontology of the Carboniferous system, especially in Staffordshire, Derbyshire, Lancashire and North Wales. His research has on two occasions earned awards from the Geological Society of London. His work in south-west Lancashire was directly responsible, in 1939, for the discovery of a small oil-field at Formby. In the North Staffordshire coalfield, he was largely responsible, while with the Geological Survey, for the six-inch re-mapping, and his considerable local experience, both above and below ground, in this field is a particularly valuable asset to his work at Keele, where in three years he has built up a large department (soon to move into new premises). In an academic curriculum in which some science is insisted on for all students, geology is a popular subject; but Dr. Cope has also a flourishing honours school, and is contributing to the training of geographers, who are required to take a year's geology.

Technological Education in Great Britain

In an address to the Union of Lancashire and Cheshire Institutes given at Lancaster on October 2, Mr. Lincoln Gordon, minister for economic affairs at the American Embassy, London, and chief of the United States Foreign Operations Administration Mission to the United Kingdom, suggested that even if all the various means of expanding technological education—by the expansion of existing technological departments of universities, development of existing technological colleges, or the establishment of one or more independent institutions on the lines of the Massachusetts Institute of Technology—were pushed to the furthest practicable limits, the resulting expansion would not surpass the ever-growing needs. The best technological training in Britain, he said, is second to none; but technological education should also reflect the growing part of the engineering profession as a source of general industrial management: education for management should become an important adjunct of higher technological training. Mr. Gordon is convinced that the science and art of management could, in large and increasing measure, be analysed, systematized and communicated to others: administration could be a genuine discipline. Properly handled, the case method can greatly enhance the student's ability to assume practical responsibilities and to contribute constructively to the operation of his firm. However, young men and women who have several years of experience in industry or business, owing to that background and their greater maturity, are much better students of administrative subjects than those newly graduated; there are other advantages, too, such as the elimination of wastage, and an earlier start on a useful career, when entry on such courses is deferred. Mr. Gordon also suggested that Britain might have something to learn from American experience in providing a greater number of intensive short-term courses, similar to those already existing at the Administrative Staff College, Henley, for men with ten to twenty years of experience in industry who might be considered for promotion to the highest posts of general management.

Science Teachers in Scotland

The Secretary of State for Scotland has appointed the following committee to advise him on the supply of mathematics and science teachers in Scotland: Sir Edward Appleton (*chairman*); Prof. E. T. Copson, professor of mathematics, University of St. Andrews; Prof. J. M. Graham, Lord Provost of Aberdeen; Mr. A. G. McKimmie, headmaster of Allan Glen's School, Glasgow; Dr. A. R. Murison, rector of Marr College, Troon; Dr. H. B. Nisbet, principal of Heriot-Watt College, Edinburgh; Mr. H. P. Wood, director of studies, Jordanhill Training College, Glasgow; and Mr. A. L. Young, director of education, Aberdeenshire.

Oil Pollution Research: Plotting of Currents in the North Atlantic

The National Institute of Oceanography will shortly initiate an intensive research into the surface currents in the North Atlantic to the west of the British Isles as part of the campaign against the pollution of the beaches of Britain by oil residue jettisoned by ships. It is planned to drop into the sea some ten thousand plastic envelopes, each containing a numbered card carrying the date and position in which each is dropped. Finders will be

asked to write on the postcard their name and address, and the date and place of recovery of the envelope. The instructions will be printed in eight different languages. A reward of half-a-crown, or its equivalent in foreign currency, will be paid to the sender of each postcard which is received by the National Institute of Oceanography, Wormley, near Godalming, Surrey. Dropping will be carried out from Coastal Command aircraft on navigational training flights. The dropping track will run from the Bay of Biscay, roughly in a semicircle of 500 miles radius, to a point halfway between the Hebrides and Iceland, and will thus stretch from side to side of the belt of current travelling north-east which crosses the Atlantic in these latitudes. In order to learn more about seasonal changes in the currents, about two thousand envelopes will be dropped in early spring, autumn and winter of 1954; double that quantity will be released in early summer, when the chances of recovery by holiday-makers between one and three months later will be greater than during the other seasons. The dates on which the envelopes will be dropped will be announced later.

Radio Observations of Meteor Streams

Two of the papers in Astronomical Contributions from the University of Manchester, Series 1: Jodrell Bank Annals (1, No. 2, 13; December 1952) deal with the radio-astronomical work at Jodrell Bank on meteors. The first paper, by Mary Almond, K. Bullough and G. S. Hawkins, with the title "Radio Echo Observations of the Daytime Meteor Streams in 1952", is a continuation of the work of previous years on the daylight meteor streams. The same equipment as was formerly used was utilized for measuring meteor velocities, the accuracy of an individual determination being $\pm$ 5 per cent, and radiants were delineated with an accuracy of $\pm$ 1° in right ascension and $\pm$ 1·5° in declination. Five tables give the necessary information on such matters as mean hourly rate, maximum hourly rate, meteor velocities, etc., and the following interesting points emerge as a result of the work. As the η Aquarid radiant appeared in its normal position at the expected value of the sun's longitude, it is assumed that the anomalous displacement of 20° observed during 1951 was probably due to a spurious grouping of sporadic meteors. The mean radiant position, mean velocity and orbital elements of the daytime Arietids are compared with those obtained during 1950 and 1951, and the results are in good agreement. A mean ephemeris for the motion of the radiant of the daytime Perseids, combining the results for 1950–52, shows that this motion, and hence the structure of the stream, are similar to those of the daytime Arietids. The ephemeris of the radiant motion of the daytime β Taurids, obtained by combining the results for 1952 with those for the previous two years, shows that the motion is eastward and towards the ecliptic. The mean orbit again confirms the close association of this stream with the night-time Taurid stream and Encke's comet. The second paper, by Mary Almond, deals with the observations made during July 1952 to determine the velocity of the δ Aquarid meteors, and the mean velocity has been used to compute an orbit which has a strong resemblance to that of the daytime Arietids. The orbits of both streams, projected on the plane of the ecliptic, are shown. Calculations show that the δ Aquarids are 0·31 astronomical unit away from the earth at the second approach on June 9 and that the width of the daytime Arietids must be at least 0·27 astronomical unit. It is considered probable that the connected showers are produced by one extended stream.

Earthquake Damage and the Nature of the Ground

THE relation between earthquake damage and the nature of the ground has been examined by Kiyoshi Kanai, Teiji Tanaka and Tomisaburo Suzuki in a recent paper on this subject (*Bull. Earthquake Res. Inst. Tokyo Univ.*, 31, Pt. 1, 57; March 1953). The earthquake considered was the Tokachi-Oki one of March 4, 1952, which had an instrumental magnitude of 8·1. The numbers of totally destroyed, semi-destroyed and slightly damaged houses in the south and east parts of Hokkaido were about 1,400, 5,400 and 15,000, respectively. The main public buildings were damaged more seriously than ordinary houses, since the upper parts of the houses in Hokkaido are very light. Destruction occurred in an area in which peat covered a clay sub-soil, though the destruction in an area surrounding a point (*A*) 2·2 km. south-south-west of Iked station was not so great as in an area surrounding a point (*B*) 2·9 km. south-west of the station. A geophysical prospecting survey gave the following results.

Place	Velocity of *P*-waves (m./sec.) First layer	Second layer	Thickness of first layer (m.)
A	350	1,400	15
B	150	1,300	2

The largest amplitude at a free surface is caused by a wave of which the period is equal to the natural one of the object under consideration. With the above results and assuming that Poisson's ratio in both layers is 0·48 and that the densities of materials in the layers are 1·5 and 2·0 gm./cm.^{3}, respectively, then ξ/v^3 for (*A*) is $7{\cdot}6 \times 10^{-7}$ c.g.s. units and for (*B*) is $15{\cdot}2 \times 10^{-7}$ c.g.s. units. Assuming the amplitude in any period of incident waves at the boundary to be constant, the ratio of surface ground displacements $A : B$ is 2 : 1, and the ratio of the surface accelerations $A : B$ is 20 : 1. Assuming equipartition of energy for waves of different periods, the ratio of amplitudes (displacements) $A : B$ is 0·62 : 1 and ratio of surface accelerations $A : B$ is 6·2 : 1. Hence the periods of the waves at (*A*) and (*B*) which have predominant amplitudes become $4H/v_s = 0{\cdot}9$ sec. ($\equiv T_A$) and 0·3 sec. ($\equiv T_B$). The natural period of top-light farm-houses peculiar to Hokkaido appears to have been approximately 0·3 sec., and thus according to the above work, in the case of a great earthquake, the houses in (*B*) district would be under worse vibrational conditions than those in (*A*) district—as was observed.

Geological Structure of the Russian Platform

DR. S. I. TOMKEIEFF has rendered a valuable service to geologists by summarizing recent work in the U.S.S.R. on the structure of the Russian Platform; his paper (*Proc. Geol. Soc. London*, July 15, p. 108) is accompanied by a map of the pre-Devonian surface of the Platform. Karpinski's conception in 1886 was that the Lower Palæozoic deposits extended from the Baltic Sea region across the Platform in an easterly direction towards the Urals. During recent years, using the data provided by a large number of borings, Shatsky has made this conception more precise and has recognized the existence of a com-

paratively shallow downwarp of the Platform—designated the Moscow 'syneclise'—extending from the Baltic Sea between Leningrad and Moscow and then turning sharply to the north. The unmetamorphosed Pre-Cambrian rocks which form the lowest part of the sedimentary cover of the Platform are called by Shatsky the Rhiphæan Group. The transgression of the Cambrian over the latter can be traced all along the border of the Fennoscandian Shield; thus the Rhiphæan is apparently equivalent to the Eocambrian or Sparagmitian of Norway. Shatsky even wishes to apply the term Rhiphæan to other similar deposits, such as the Sinian, found in China, Siberia, India and elsewhere; but in the absence of palæontological means of correlation, it is obvious that local names cannot yet be superseded. Shatsky's map shows the Rhiphæan–Lower Palæozoic syneclise (downwarp) separating the Baltic and Sarmatian Shields. The latter is divided by a narrow Rhiphæan trough into the Uralian–Volga massif on the north-east and the Kiev–Voronesh massif on the south-west.

Synthetic Materials in Picture Conservation

An important paper in the September issue of the *Museums Journal*, by Arthur Lucas and Norman Bromelle, of the National Gallery, London, deals with the failure of certain synthetic materials in picture conservation. They maintain that during the past few years a number of statements have appeared in the national and technical press which give the impression that newer materials discovered by the organic chemist are superior to the traditional varnishes, media and adhesives used hitherto. This paper has been written to warn restorers and conservators of the dangers incurred in accepting recommendations from partisans of the products of modern chemical industry. Mr. Lucas and Mr. Bromelle believe that modern synthetic materials have not fulfilled their promise for probably two reasons. First, the natural materials, glue, egg, natural resins, etc., are invariably complex in composition, each containing a large range of different substances often highly complex in themselves; in the process of forming, say, an adhesive bond, these different ingredients all play their part in reinforcing each other, so that in all the variations in surface properties of the parts to be attached the glue is sufficiently versatile to adapt itself. Secondly, a picture is composed of layers of wholly natural materials, apart from the pigments, and its response to external conditions (temperature, humidity, etc.) depends on the combined physical properties of these materials; the natural materials used in conservation can be made to harmonize readily with these properties, but the harmony is far more difficult with artificial materials. Full details of many of these new synthetic materials and their reactions are given in the paper quoted.

The Musk-Ox

First recorded by an English youth so long ago as 1689, the musk-ox forms the subject of an interesting article by R. Glover in a recent issue of *Oryx* (2, No. 2). The musk-ox is a little-known Arctic mammal. Generally, these animals feed on moss but, when this is scarce, have been known to feed on the young twigs of willow, pine and even elm trees. They are gregarious, and each cow probably produces one calf every two years. One of the natural enemies of the musk-ox is the wolf; to resist attack by the latter, musk-oxen often stand, horns outward, in a bunch, practising a characteristic defensive drill. Apart from the use of the skin as warm robes, the animals have suffered little commercial exploitation by man and, although the musk-oxen have disappeared from wide areas they once inhabited, adequate stocks still remain. At present there are some prospects of domesticating the animal and this is causing some speculation in North America. Mr. Glover believes that the best way of making the musk-ox serviceable to mankind is not by domestication but by intelligent game management in its native home.

The Philosophy of Numbers

In a communication to the Eleventh International Congress of Philosophy, held in Brussels during August 20–26, Prof. D. Riabouchinsky gave a summary of the ideas he has developed and published in a series of papers for forty years. His communication, which is entitled "La Définition des Nombres par leur Valeur numérique et par leur Origine; Rôle de ce Concept en Philosophie mathématique", is published in Vol. 5—Logic, Philosophical Analysis, Philosophy of Mathematics—of the proceedings of the Congress (Amsterdam: North Holland Publishing Co.; Louvain: Éditions E. Nauwelaerts, 1953). The ideas presented are so different from those usually held that they have been misunderstood or rejected without examination. The author does not consider two numbers as equal, even if they have the same numerical value, if they arise in a different manner: for example, $\sin \pi/2$ and $\sin 5\pi/2$, both of which have the numerical value 1. Moreover, he distinguishes between Euclidean points, which are the extremities of lines, and dimensional points, which are the limits obtained by reducing to zero a length, surface or volume. The importance of this distinction is that it leads the author to reject certain well-known theorems in the theory of sets, such as Cantor's theorem that the number of points in a square is equal to the number in one of its edges. Another aspect of the author's point of view, and one more difficult to understand, is a theory of a new kind of imaginary numbers, which is associated with a principle attributed to Kant. He has also a general theory of algebraic equations which contain the symbol for absolute value, but details are not given here.

Research on Kilns in Japan

Among the various topics discussed in Bulletin No. 60 of the Government Forest Experiment Station (Meguro, Tokyo; March 1953) various aspects of the kilns used in Japan are considered. Experiments are being made with different types of charcoal kilns in four different provinces in Japan, and the methods of construction are outlined. Other experiments are connected with drying-kilns. Before the Second World War most of the kilns in Japan were of the natural ventilated type, its inadequacy being due to the impossibility of drying the boards evenly and quickly. After the War, the Sturtevant kiln was built, but its use in Japan has not apparently been satisfactory. The faults that have been discovered and the tests made on the kiln are all described in the bulletin.

Indian National Scientific Documentation Centre: Report for the Year 1952–53

The first annual report, for the year 1952–53, of the Indian National Scientific Documentation Centre

has now been published (pp. 13; from the Centre, New Delhi, 1953). The Centre was set up on July 7, 1951, under an agreement with the United Nations Educational, Scientific and Cultural Organization, providing for technical assistance over three years. It is situated in the National Physical Laboratory of India, New Delhi, and is under the administrative control of Sir K. S. Krishnan, assisted by an advisory committee. All possible steps are being taken to obtain and hold copies of scientific periodicals required in India, particularly by the universities, scientific research organizations and government laboratories, and the Centre is now in a position to supply to any country a copy of an article published in any Indian scientific periodical. Other functions of the Centre are to prepare an index of periodicals available, to act as a national repository for reports of Indian scientific work, to deal with inquiries, and generally to act as a means of making the scientific work of India and the surrounding countries known and available to the rest of the world. Three scholarships were provided by Unesco during 1952 for training suitable candidates in special fields of study relating to the project. The information service has been organized and the translation service supplemented by a panel of translators on which twenty-three persons are at present enrolled, and it is proposed to issue a monthly bibliographical bulletin giving the titles of scientific papers published in Indian and foreign periodicals and a list of translations available.

Current Periodicals in the Science Library, London

THE seventh edition of the "Hand List of Short Titles of Current Periodicals in the Science Library" (pp. 388; London: H.M.S.O., 1953; 10*s*. net), which was first published in 1904, contains about 8,500 titles of periodicals now being received, compared with the 7,000 entries of the sixth edition (1950). The order of entries is that of the "World List of Scientific Periodicals", with the exception that periodicals which have distinctive titles commencing "Journal", "Bulletin", etc., follow journals, bulletins, reports, etc., of societies, institutions, etc., and do not appear in one alphabetical order. Thus, the "Journal of Allergy" is not placed between "Journal, Alabama Academy of Science" and "Journal, American Ceramic Society", but after "Journal, Yorkshire Agriculture Society". In all entries, the dates following the semi-colon are dates of publication; but the range of years covered by a single report, and the years covered by runs and any gaps in a series of volumes, are also indicated. There are no cross-references, but extra entries are made under alternative forms of the title; and although a periodical is entered only under its current title or titles, the heading shown is inclusive of its earlier titles. Shelf-marks are given at the end of the entries and should be quoted by all users of the list so as to expedite service.

Finances of the United States National Science Foundation

A FURTHER inquiry by the National Science Foundation indicates that Federal agencies in the United States spent 1,839 million dollars on scientific research and development during the fiscal year 1952, the corresponding estimate for 1953 being 2,189 million dollars, and the president's budget of January 9 included 2,327 million dollars for the year 1954. During each of these years funds administered by the Department of Defense amounted to 72 per cent of the total, compared with the 14 per cent for the Atomic Energy Commission and 4 per cent for both the National Advisory Committee for Aeronautics and the Federal Security Agency. During 1952, 307 million dollars was allotted for increase of existing research facilities or construction of new laboratories, 198 million dollars of this going to the Department of Defense and 60 million to the Atomic Energy Commission.

University of Sheffield

THE United Steel Companies, Ltd., have established a research fellowship in metallurgy in the University of Sheffield, tenable in the Department of Metallurgy, the object of which will be to advance metallurgical knowledge and not to train persons for research. Appointments to the fellowship will be made from time to time from among scientific workers who have already served their apprenticeship in research and have shown ability to conduct independent investigations. The field of study within which they will be expected to work will be ferrous metallurgy, but this does not exclude the appointment of researchers in refractory matters, knowledge of which is of great importance in ferrous metallurgy. The fellowship will be worth at least £750 for the first year, rising by annual increments of £50, and will be normally held for five years.

The following have been appointed lecturers in the University of Sheffield: K. H. Sutherland and E. P. Bernat (mechanical engineering); Dr. W. Eastwood and C. Osgerby (civil engineering); and F. G. West-Oram (glass technology).

Institute of Navigation: Officers for 1953–54

THE following have been elected officers for 1953–54 of the Institute of Navigation: *President*, D. H. Sadler, superintendent of H.M. Nautical Almanac Office; *Vice-Presidents*, Air Chief Marshal the Hon. Sir Ralph Cochrane, formerly Vice-Chief of the Air Staff, and Captain F. J. Wylie, R.N. (ret.), director of the Radio Advisory Service; *Honorary Treasurer*, Francis Chichester; *Chairman of the Technical Committee*, Wing Commander E. W. Anderson; *Chairman of the Executive Committee*, Captain G. C. Saul, deputy master of the Honourable Company of Master Mariners.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: R. B. Allnutt (assistant director of agriculture, Nigeria), deputy director of agriculture, Western Region, Nigeria; M. A. G. Hanschell (agricultural officer, Sierra Leone), development commissioner, St. Lucia; C. A. S. Hynam (agricultural officer, Trinidad), agricultural officer, British Honduras; A. Jefferiss (agricultural officer, Tanganyika), director of agriculture, Seychelles; E. A. Tai (senior agricultural officer, Jamaica), agronomist, Trinidad; E. H. Jaques (geologist, Federation of Malaya), principal geologist, Federation of Malaya; H. E. F. Savage (principal geologist, Federation of Malaya), deputy director, Geological Survey, Federation of Malaya; G. H. S. Wood (assistant conservator of forests, Uganda), senior scientific officer, forest botanist, North Borneo; E. Millington (senior agricultural survey officer, Gold Coast), principal agricultural survey officer, Gold Coast; V. I. Mulloon (senior agricultural assistant,

Trinidad), soil survey officer, Trinidad; R. M. S. Neave (veterinary officer, Kenya), chief veterinary officer, Cyprus; E. Pienaar (field officer (agriculture), Tanganyika), superintendent of agriculture, Tanganyika; C. M. Taylor (education officer, Kenya), meteorologist, East African Meteorological Department, East African High Commission; R. J. R. Barrett, G. I. M. Martin and C. R. Raper, agricultural officers, Federation of Malaya; P. A. P. Dawson, geologist, British Solomon Islands Protectorate; A. J. Crosbie, soil survey officer, Department of Soil and Land Use Survey, Gold Coast; J. C. Duerden, scientific officer, Nigeria; W. R. V. Lort, cultivation officer (Department of Science and Agriculture), Barbados; J. A. Spence, plant pathologist, British Guiana; R. M. Thompson, geologist, British Solomon Islands Protectorate.

Tenth World's Poultry Congress, Edinburgh

The Tenth World's Poultry Congress will be held in Edinburgh during August 13–21, 1954, under the auspices of the World's Poultry Science Association, and will be organized by the Department of Agriculture for Scotland. For the sessions on the reading of papers the Congress will be divided into five sections covering the following topics: genetics and breeding; physiology and nutrition; diseases and their control; economics and marketing; and husbandry and miscellaneous. Any person may submit a paper to be read at the Congress, whether or not he is a member of the World's Poultry Science Association. Papers should be 1,500–3,000 words in length, written in English or French, and must be accompanied by a résumé not exceeding 300 words in the same language. Those intending to submit papers should send in the title to the Congress Secretariat before October 31, 1953, and the full text before January 1, 1954. Further information can be obtained from the Secretariat, Tenth World's Poultry Congress, St. Andrew's House, Edinburgh 1.

Origins of Resistance to Drugs: Symposium in Washington, D.C.

A symposium on the origins of resistance to drugs, etc., is being organized by the United States Office of Naval Research and the University of Pennsylvania and will be held in Washington, D.C., during March 25–27, 1954. The symposium will consist of five successive sessions devoted, respectively, to the following topics: the origins of microbial drug resistance; tolerance and addiction to drugs, and alcoholism; resistance to insecticides and herbicides; factors in resistance to infectious agents, the biochemical mechanism of carcinogenesis and the nature of tumour immunity; and a concluding session devoted to the integration of the questions of resistance from the genetic, physiological and chemical points of view. Papers will be given by invited speakers, followed by open discussion from the audience. Application forms and further information can be obtained from Dr. M. G. Sevag, Department of Microbiology, School of Medicine, University of Pennsylvania, Philadelphia 4, Pennsylvania.

International Council for Electrodeposition: Conference in London

At the first meeting of the newly constituted International Council for Electrodeposition, which was held recently in London at the headquarters of the Institute of Metal Finishing, plans were laid for the forthcoming international conference to be held in London during April 21–24, 1954. A large number of overseas delegates are expected to attend, in particular a strong contingent from the United States, and it is hoped to organize a special session to discuss the latest American practices in electrodeposition. The Institute of Metal Finishing has arranged that on the eve of the international conference the Hothersall Memorial Lecture for 1953–54 will be given by Dr. William Blum, who is well known in the field of electrodeposition through his study of electrochemical processes and other problems. Membership of the International Council is open to technical societies and institutes throughout the world with interests in the field of electrodeposition. They are invited to write in the first place to the honorary corresponding secretary of the Council, Dr. S. Wernick, Institute of Metal Finishing, 32 Great Ormond Street, London, W.C.1.

Glassware for the Laboratory

Two well-known British manufacturers of laboratory glassware have recently published catalogues which should be of interest to a wide range of scientific workers. One of the firms, Quickfit and Quartz, Ltd. (Heart of Stone Works, Staffs), has a list giving the prices of apparatus made by them and also an illustrated catalogue giving full particulars. The taper on 'Quickfit' ground-glass joints agrees with that specified in British, American, Belgian, Czech, Dutch, French and German standards. The catalogue also illustrates many assemblies of apparatus which can be made from parts supplied by the firm. The other catalogue is from James A. Jobling and Co., Ltd. (Sunderland, Co. Durham), the sole manufacturer in the United Kingdom of 'Pyrex' laboratory and scientific glassware. The descriptions and prices are given of a large range of apparatus; the joints of parts that can be assembled are interchangeable. The firm will also make special apparatus in 'Pyrex' glass to designs of users.

Announcements

Mr. D. N. Lowe, secretary of the British Association, has been appointed secretary of the Carnegie United Kingdom Trust in succession to Mr. James Wilkie, who is due to retire on March 31, 1954.

A meeting on "Re-establishing Scientific Contacts with the U.S.S.R." will be held under the auspices of Science for Peace at Denison House, 269 Vauxhall Bridge Road, London, on October 28 at 7.30 p.m. Prof. K. Lonsdale will take the chair and the speakers will be Dr. J. S. D. Bacon, Prof. J. D. Bernal, Dr. D. M. Crowfoot Hodgkin, Dr. A. H. Gordon and Prof. J. H. C. Whitehead. Questions and discussion will follow. Tickets (price 1*s.*) can be obtained from Science for Peace, 49 Flower Lane, London, N.W.7.

The Nutrition Panel of the Food Group of the Society of Chemical Industry will be holding a series of meetings during the session 1953–54 under the general title of "Nutritional Appraisals". The first meeting will be held in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1, at 6.30 p.m. on October 28, when Dr. A. E. Bender will discuss proteins. Other meetings in the series will deal with calories and basal metabolism on December 9 and vitamins on January 27. Further information can be obtained from the honorary secretary of the Panel, L. C. Dutton, Virol, Ltd., Hanger Lane, Ealing, London, W.5.

NEW PHYSIOLOGICAL LABORATORY AT OXFORD

A NEW Physiological Laboratory has been built in Oxford, at a cost of £300,000, and is now coming into use. It has been designed by Prof. E. G. T. Liddell, Waynflete professor of physiology in the University, in consultation with the architects, Messrs. Lanchester and Lodge.

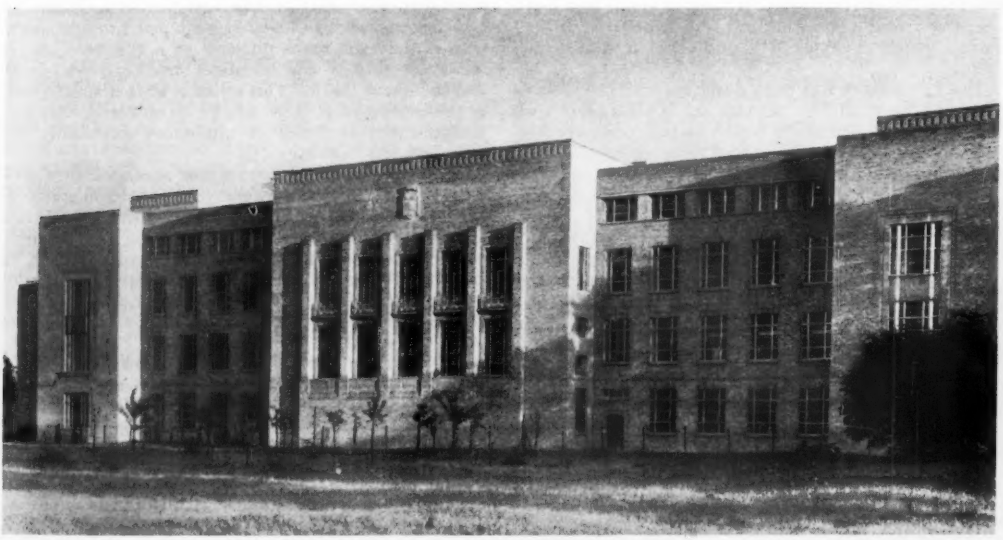
The old laboratory was begun in 1883 and cost £10,000. In those days the annual intake of students was small—seven in 1887. In 1908 a new block for physiological chemistry was added, at a cost of £5,500. The building could then accommodate an optimum number of twenty-five students a year, and in 1914 the number was twenty-six. Severe strain was first felt in the wake of the First World War: the 1923 class numbered 63. In 1926 things were made easier by the foundation of the Department of Biochemistry, in that bench space for the whole of 'chemical physiology' was no longer needed in the old laboratory. But student numbers never fell to the pre-War level: the number of class-meetings attended by each student had to be cut down, classes had to be duplicated, and the need for a new laboratory became every year more urgent. The late Prof. John Mellanby planned a £102,000 building in the late 1930's, but this had to be given up in 1939. The newly built Laboratory will bring relief to students and teachers alike, for the 1952–53 class numbered 79, exceeding by threefold the capacity of the old classrooms.

The new building is of stone-coloured brick. It has four stories, three staircases and goods and passenger lifts. It is long and narrow, 360 ft. long and 75 ft. wide at its centre. This shape, imposed by the shape of the only available site, gives a spurious impression of vastness which can only be corrected by viewing it end-on. It provides bench space for an annual intake of a hundred students. Research accommodation is also increased, but not in proportion to the increased room for teaching.

The main entrance hall and large lecture theatre together fill a large part of the centre of the building, and are two stories high. The lecture theatre seats 250, in fourteen parallel, steeply sloped tiers. At the back are external projection and rewinding chambers, and beneath these a glass-fronted gallery whence late-comers may see what goes on within, and whence they may unobtrusively enter. For demonstrations there is an oval well-shaped theatre with leaning-space for a hundred spectators. Also on the ground floor are two classrooms for muscle–nerve experiments; a darkened classroom for ophthalmic work; the main engineering shop; and four research rooms (one of them screened from electrical interference), with their photographic dark-rooms and office and workshop accommodation.

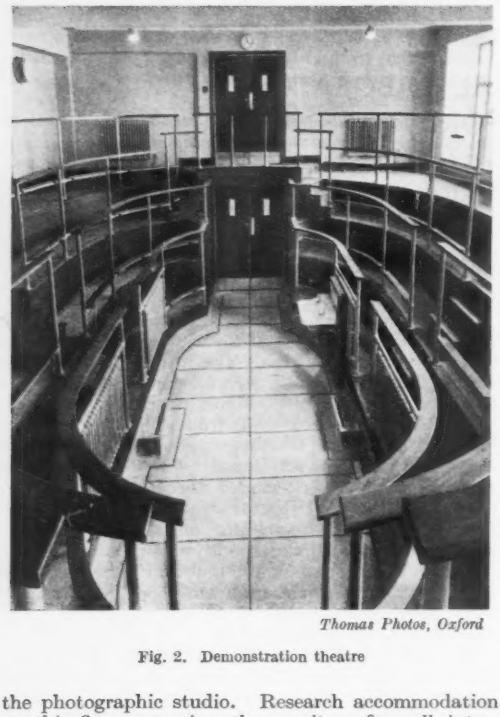
On the first floor are the professor's offices, and two research rooms, with dark rooms, for himself and his associates. Human physiology has two classrooms and three research rooms, one of which incorporates a cold room. The staff common room is on this floor.

The second floor has a small lecture room seating 85; a large classroom for histology, and a smaller one for more advanced histological work for the senior class; classrooms for mammalian physiology and for advanced electrophysiology; the library; and



Thomas Photos, Oxford

Fig. 1. Department of Physiology, University of Oxford



Thomas Photos, Oxford

Fig. 2. Demonstration theatre

the photographic studio. Research accommodation on this floor comprises three suites of small interconnected rooms adapted to the needs of microscopical work.

The third floor opens out on to a large area of the whole length of the second-floor roof, which can be used for experimental work on muscular exercise, the subjects' courses being timed from the bay windows of a special observation room. On this floor are the operating theatre and X-ray room; an observation room for the psychological testing of small and large primates; and a spacious and well-ventilated animal house, which includes a sound-proofed dog-kennel room.

The Laboratory has been designed with the view of maximum adaptability of purpose. Rooms filled with extensive and permanent bench installations are few, and most of the classrooms and research rooms could be differently divided and furnished from time to time, as changing interests and emphasis may require.

Enough has probably been said to show that Oxford's problem of inadequate bench space for physiology has been solved. Elementary instruction will now be possible without strain; and a start can be made with the re-expansion of the content of the courses in advanced physiology. The extent and direction of this expansion must, of course, depend on the interests of the research workers who form the teaching staff. Its pace will depend on the rate at which financial stringency will allow reinforcement of their numbers to a level which will restore the student–teacher ratios of the senior classes of former days. For there is to be no weakening of the traditional policy which strives to place before the large majority of Oxford medical students educational opportunities which are elsewhere restricted to men and women proposing to specialize in biological research.

NINTH INTERNATIONAL CONGRESS OF GENETICS

THE post-war trend in international scientific meetings has been towards small symposia and conferences, and, as a consequence, there are now considerable opportunities for contact between those working within each of a number of limited fields. The main function of international congresses has become the complementary one of discussion between workers in different branches of broader fields. On this standard, the Ninth International Congress of Genetics, held this year in Bellagio during August 24–31, has been more successful than the two preceding ones (Edinburgh, 1939; Stockholm, 1948), and the organizing committee deserves the gratitude of all the members who participated.

The reasons for this success are essentially twofold. First, the number of participants—more than eight hundred—though somewhat larger than at the Eighth Congress, was still small enough for everyone to meet everyone else. With numbers exceeding, say, one thousand, personal contacts outside the sessions can only be selective and require deliberate planning. Second, the Congress was centred not on a town but on a small and quiet holiday resort. In Bellagio, members of the Congress were accommodated in hotels along a short stretch of the shore, and most of the cafés were in the same stretch: thus meeting, or looking for, any member outside session time was only a matter of walking a few yards. Unfortunately, Bellagio could not accommodate all the members: part were accommodated ten minutes away by boat across the lake, and the two groups became effectively separated in the evening.

The plenary sessions of the Congress were held in the dining-hall of a big hotel, with unsatisfactory acoustics and ventilation, and the sectional sessions were held in the classrooms of a local school, some of insufficient capacity. These shortcomings were the price to be paid for by choosing a locality without the facilities of a university, but it was well worth paying in view of the other advantages. There are two lessons which this Congress has brought home. One is that the main purpose of a congress can be achieved only if the numbers are kept well below the thousand mark. The other is that a small centre is preferable to a large town; if it could also have lecture-room facilities of university standard, then so much the better.

The work of the Congress was arranged in a novel way. The afternoons were reserved exclusively for plenary sessions, each with three or four invited papers—twenty-seven in all. During the mornings there were eight special sessions simultaneously for papers of fifteen minutes length (about three hundred in all). These special sessions were interspersed with invited lectures (fourteen in number), not overlapping with one another.

It would be impossible to give here more than an idea of trends in genetics, as detectable at the Congress.

The study of the part the genes play in the function of the cell, and secondarily in the organism, has become one of the central fields in genetics. This trend can be detected quite clearly even in indirect approaches: for example, researches on the arrangement of the genes along the chromosomes, on the induction of specific mutations, on the process of mutation itself, and even on quantitative inheritance,

are all strongly biased towards this functional aspect. The opening address of the president, Prof. Richard Goldschmidt, on what he called the dynamic versus the static approach in genetics, put into a nutshell what became increasingly clear as the work of the Congress proceeded.

Another impression from the papers presented at the Congress is that the microscopic study of the chromosomes has reached an impasse, except as a branch of comparative morphology: it is waiting for substantially new techniques and substantially new ideas. As for the former, there was one demonstration on electron microscopy of chromosomes in meiosis which was of enough interest to suggest that this might be one of the new techniques.

The genus *Drosophila* has now come back into its own for a new purpose: the study of natural populations. Under the stimulus of genetic investigation so much work has been done on the systematics, the ecology, the comparative anatomy (including comparative karyology) of the innumerable species of *Drosophila* that this genus is now the ideal tool in this field.

The numerous papers presented showed that the interest in quantitative inheritance has expanded enormously since the last Congress. If its exponents can keep the distinction between statistical tools and biological ends clear, this is obviously a field of great future importance.

As to human genetics, there is a growing interest both in the study of inheritance of particular conditions and of the comparative genetics of populations. Indeed, man takes now a rank not far from that of *Drosophila* and of micro-organisms as a subject for genetic research.

The Congress will certainly give fruits both in the direction of personal friendship, renewed or promoted *de novo*, and of new ideas arising from cross-fertilization.

G. Pontecorvo

INDUSTRIAL RESEARCH DIRECTORS

THE report of the third Conference of Industrial Research Directors and Research Managers, organized by the Industrial Research Committee of the Federation of British Industries, which was held at Ashorne Hill during April 17–19, 1953, has now been published*. The main subject of the conference was the commercial utilization of research results, and the report thus deals with an aspect of productivity with which the Advisory Council on Scientific Policy and the Department of Scientific and Industrial Research are increasingly concerned. Dealing with the problem from the point of view of company management, Lord Baillieu, who outlined policy and practice in the Dunlop Rubber Co., urged that it is essential to operate within our resources of finance, man-power and equipment. Research programmes should be conceived and keenly reviewed in terms of the conditions which a new idea or discovery must meet to achieve success; but we should not lose sight of the wider horizons and fundamental researches which have challenged the ingenuity and courage of men, and to which the British genius has responded so outstandingly. From the production point of view, Mr. G. S. Samways thought that in the metal container industry science has opened the way to revolutionary rather than evolutionary changes; research presents a problem not in finding ideas or in the method of implementation, but in finding the right type of young men and the large capital investment required. From the research point of view, Dr. N. P. Inglis urged the importance of a full and harmonious relationship between research and production departments. Elimination of problems of understanding, communications, joint consultation, etc., is largely a matter of personnel, and particularly of securing the right personnel and moving them about in the right way in their early years. Mr. E. R. Davies, describing the relations between research work and production in Kodak, Ltd., emphasized the way in which collaboration between plant and research workers is fostered by frequent informal as well as formal contacts, though the manufacturing departments are not paralleled entirely by laboratory groups in the research department; the four main types of manufacturing activity have been kept successfully in touch with development work and research groups through a system of four senior co-ordinators. Mr. J. B. Mitford stated that in Fibreglass, Ltd., the production department looks to the research department for new manufacturing methods, or revolutionary improvements in existing methods, for the rapid tracing and elimination of causes of trouble in regular manufacture, and for the provision of a testing and advisory service on raw materials and finished products. Frequently, he admitted, the production side is at fault in failing to give the whole of the facts, and he stressed the necessity of research and development men establishing a high reputation with the junior management and production people at the foremen-level.

The papers on utilization of research results as a sales problem, whether from the sales or the research point of view, and the subsequent discussion indicated that it is not quite so easy to establish a satisfactory relation between research and sales departments as between research and production departments. The essential point seems to be to maintain a proper balance and relation in the traffic of ideas between the two departments, and it is desirable that the practical experience of the sales side should receive full consideration in any discussions on the shaping of research and the evaluation of research progress. There is a place for creative-minded scientists with commercial instincts in the sales organization, in order to digest the import of sales intelligence and translate it into research ideas; but Dr. H. E. Merritt pointed out that it is also essential that the product situation should be reviewed, past performance appraised and probable future trends analysed at a high level in management. Much discussion centred on the training of salesmen, though the need for technical training was also fully recognized.

The fourth session was concerned with creating the right atmosphere. This, Mr. H. C. H. Graves urged, is partly a matter of human relations, and he thought there is room for some research into administrative methods, etc., of improving co-operation. If the importance, integrity and dignity of the individual are recognized, group attitudes would adjust themselves satisfactorily: the important thing is to encourage the right overall attitude to the economic objectives of the firm and industry, and appreciation

* Federation of British Industries. Report of the Third Conference of Industrial Directors and Managers, Ashorne Hill, 1953. Pp. vi+70. (London: Federation of British Industries, 1953.) 3s. 6d.

of the individual as a participant in a team working for a common end. Mr. H. W. G. Hignett maintained that the preservation of good relations between the research department and other departments depends mainly on mutual respect, which can be engendered in many ways, not all of them technical. From a purely technical point of view, Mr. Hignett urged that four maxims should be observed: never give advice until all relevant facts are known and the background is clearly understood; with this proviso, never fear to criticize when constructive criticism is in the company's interest; never relax efforts to make research reports concise and clear; and, wherever possible, let other departments take more than their fair share of the credit for exploiting the results of research. Finally, to secure full value from the research effort of Great Britain, we need a little more imagination and a lot more courage. Discussion centred on the importance of good organization, the danger of over-organization destroying personal initiative, and the need for making all workers aware of the dependence of our economic survival upon the development and exploitation of new research ideas. The right atmosphere can be created on the basis of mutual trust in one another and in each other's integrity and sincerity of purpose.

ATHLONE FELLOWSHIP SCHEME FOR CANADIAN ENGINEERS

THE Athlone Fellowship Scheme, now in its third year of operation, is designed to bring to Great Britain every year thirty-eight Canadian graduates in engineering for postgraduate studies extending over two years. The Fellowships are tenable in industry or in a university, or may be divided between both. They cover the cost of travel to and from the United Kingdom, with a subsistence allowance of £6 10*s*. a week, the cost of tuition at a university and allowance towards text-books, and a travel grant of £25 a year for journeys within the United Kingdom. The net cost of the scheme is carried by the British Government. Some account of the operation of the Scheme was given by Dr. W. Abbott in a paper read by him on April 10 at a joint meeting of the Institutions of Civil Engineers, Mechanical Engineers and Electrical Engineers.

There are two classes of award: one for those about to graduate, on a quota basis, which ensures not fewer than two awards in each Canadian university (with the exception of New Brunswick); and, on a national basis, for those who have already graduated and are at work. The latter selection is at present experimental. The fundamental aim of the Scheme is to familiarize Canadian graduates with British industry, and it is thus desirable to ensure that as many as possible of the Fellows enter industry and saturate themselves with workshop techniques and the products thereof. Most graduates, however, have preferred to continue their studies in a university, with the view of securing a higher degree. This is due to the fact that North America is 'higher-degree conscious' to a much greater extent than is Great Britain, and research appointments in Canada invariably call for higher degrees, usually the doctorate. During 1952–53 eighteen of the Fellows opted for university training, and only nine for industrial training, as compared with twelve each, respectively, during 1951–52, and if this trend continues the basis of the Scheme may require re-examination.

The Scheme is best suited to the requirements of the graduates in mechanical, electrical and chemical engineering, the position in civil engineering being more difficult because much of the work of prime interest to Canadian engineers—for example, water conservation and irrigation schemes—lies overseas. Perhaps the most important single factor operating against the success of the Scheme is the intense demand for graduates from all branches of the engineering industry, both in Canada and the United States. Higher starting salaries, as much as 400 dollars a month, are offered, with attractive conditions. Only graduates able to take the long view are likely to offer themselves for Fellowships, and it is probable that the great bulk of the graduates with a practical bent do not apply for Fellowships but seize the opportunities now presented in Canada. So far as each individual is concerned, the success of the Scheme depends very largely on the people he meets during his training, and upon the people with whom he lives. Not all of these may be much concerned to send the young man home with a good opinion of Britain and its institutions.

CONTROL OF MULTI-RESISTANT HOUSEFLIES

By H. WICHMAND

Government Pest Infestation Laboratory, Springforbi, Denmark

AS the fly-populations on practically all Danish farms (owing to an excellent organization of the control) have developed resistance to the chlorinated hydrocarbons used as insecticides, in 1951 I examined the possibilities of safely using Parathion in fly control. Obviously it would be too dangerous to spray this substance on the walls of stables, pigsties, etc., and furthermore, the Parathion would be rapidly hydrolysed by the lime-wash with which all the stable walls in Denmark are covered.

So we looked for a cheap but still sufficiently strong material which might be impregnated with Parathion and used as strips suspended under the ceilings like festoons. In the United States, strips of metal screen treated with Dieldrin and other chlorinated hydrocarbons have been used for fly-control[1], but this material was too expensive for us, and we found gauze strips (as used for bandages) most suitable for the purpose. Laboratory investigations showed that gauze impregnated with a 2·5 per cent solution of 35 per cent Parathion had a rapid killing effect on houseflies, and that the gauze strips after suspension for two months in an air-conditioned room with a constant temperature of 25° C. and continuous air renewal still had the effect that, of flies transferred to cages covered by the strips, 96 per cent were paralysed within two hours, and 100 per cent within three hours. Then experiments were carried out in two stables seriously infested with flies. Approximately 1 m. of gauze was used for every square metre of ceiling, and after a few days the fly population had been reduced from a number of about two hundred per animal (cows, horses and pigs) to two or three per ten animals.

A report was published eventually in a Danish farmers' bulletin, and the pesticide industry began

the production of fly-strips. The industrial strips were produced in a length of 10 or 100 m. and a breadth of 2·5 or 5 cm., and contained 0·5 or 0·7 gm. Parathion per strip of 10 cm. × 2·5 cm. (2 or 2·8 gm. per sq. m.). Flies exposed to newly made strips only needed a touch to receive a lethal dose. Strips which had been in use for six months in an air-conditioned room with a temperature of 20° C. and continuous air renewal killed 100 per cent of the flies after one minute's exposure.

In the summer of 1952 such strips were used in the stables, cowsheds, pigsties, etc., of about 20,000 farms. In the summer of 1953 the strips have been used on between 75,000 and 100,000 farms, to the satisfaction of nearly all the farmers.

The effect only failed in a few cases, particularly where the strips were only used on a single farm in a village; general use eliminated the fly trouble until the end of the season.

The Danish Health Department has permitted the use of the method, and no accidents have been reported.

[1] Pimental, D., Schwardt, H. H., and Norton, L. B., *Soap and Sanit. Chem.*, **1**, 27 (1951).

CULTIVATION OF POPLARS

THE wood of poplars has for long been used for making matches, but research work during the present century has shown that it is utilizable in other industries. Mr. T. R. Peace, of the Forestry Commission, describes the work on poplars in Bulletin No. 19 of the Commission*, a publication which supersedes Forest Bulletin No. 5 (1923) and Forestry Commission Leaflet No. 27 on "Poplar Planting" (1948). The chief attraction of the poplar as a tree crop is the rapidity of its growth, for on suitable sites it grows much faster than any other tree hardy in the British Isles; and there is a good market for its timber which, in addition to matches, is used for veneers and other purposes. Propagation, which is usually by cuttings, is easy, and planting and subsequent treatment are also not difficult. The troubles are that the choice of varieties is bewildering and becomes more so with the production of new hybrids; the selection of the site for raising the crop needs care and variations in propagation and tending.

The cradle for the growing of commercial poplars lies in Western Europe, and particularly in France, Belgium and the Netherlands. The main countries with large stands of natural poplar are Sweden, Finland, the United States and Canada. It is with the object of clarifying the central position of poplar propagation and planting that the present bulletin is written, and admirably illustrated. Mr. Peace points out that our knowledge of poplar cultivation and, in particular, of the growing of poplar in woodland or heavily grassed sites is still very far from complete. The traditional practices that have long been followed on the Continent of Europe are not necessarily the best, and in any case may not always be practicable under the conditions met with in Great Britain. The published literature on poplars is very large but is most strictly specialized; only in Holland and Germany are there text-books covering all aspects of poplar cultivation, and these are in the languages of the countries.

* Forestry Commission Bulletin No. 19: Poplars. By T. R. Peace. Pp. iv+50+24 plates. (London: H.M.S.O., 1952.) 7*s.* 6*d.* net.

The increasing interest in poplar cultivation is evidenced by the number of countries which have formed national poplar commissions to promote the study of poplars and encourage their cultivation. On the initiation of the French, an International Poplar Commission was set up in 1945, holding its first meeting in Paris.

The French peasant in some parts of France has long known the poplar and the rapidity of its growth, and instances are known whereby when a daughter is born the father has planted a few rows of poplars on his land to form her *dot* when she is married.

The trees of chief interest are the white poplars, aspens, balsam poplars and black poplars. The bulletin deals with botanical description and choice of variety, sylviculture (site, nursery practice, and planting), diseases and pests (particularly insects and fungi), and properties and uses of poplar timber.

HELICAL STRUCTURE OF CRYSTALLINE DEOXYPENTOSE NUCLEIC ACID

By DR. M. H. F. WILKINS

Medical Research Council Biophysics Research Unit, King's College, London

AND

DR. W. E. SEEDS, DR. A. R. STOKES and DR. H. R. WILSON

Wheatstone Physics Laboratory, King's College, London

EXACT information about the molecular configuration of deoxypentose nucleic acid may well serve as the basis for understanding its biological function. It has been shown by X-ray diffraction[1,2] that molecules of deoxyribonucleic acid (in the form of sodium salt) exist probably in a helical configuration when in the paracrystalline state. Proof of the helical structure would be difficult to obtain from the two-dimensional view of the molecule provided by study of paracrystalline material. The regularity of the molecule is so great, however, that it may be crystallized in fibres[3,4] with a remarkably high degree of molecular order, and X-ray study[5,6] of oriented crystalline deoxyribonucleic acid has enabled a three-dimensional view of the geometry of the molecule to be obtained. The purpose of this article is to describe in a preliminary way further three-dimensional data of this kind and to suggest that proof is now available that deoxyribonucleic acid consists of two helical intertwined polynucleotide chains and to show, as a result of molecular model building, that this structure may be of the type suggested by Watson and Crick[7].

Franklin and Gosling[8] have recently published two- and three-dimensional Patterson diagrams of crystalline calf deoxyribonucleic acid, and by means of these arrived at conclusions in many ways similar to ours. The present work owes much to them and we wish to thank them for making available to us unpublished data. Further work is in progress; clearly all doubts about the basic geometry of deoxyribonucleic acid must be eliminated, for only then can the structural chemistry of its specific biological properties and the structure of nucleoprotein be approached on a sound basis.

The X-ray diffraction photograph of crystalline deoxyribonucleic acid (sodium salt) is shown in Fig. 1. In view of its very complex biological functions (for example, the genetical transforming[9] of bacteria) it is remarkable that its crystallinity is so perfect, for such crystallinity indicates a large element of molecular simplicity. We have found no difference in the diffraction patterns of crystalline deoxyribonucleic acid obtained from calf thymus, mouse sarcoma, human white blood cells, *E. coli*, pneumococcus and *Paracentrotus* sperm, although the ratio of bases in the deoxyribonucleic acids varies considerably with species. These facts, combined with the irregularity of sequence of nitrogen bases[10] and the hydrogen bonding between bases[11], produce a contradiction which is only resolved by a simplifying concept such as the specific pairing of bases suggested by Watson and Crick[7].

A qualitative view of the X-ray photograph shows several main features which point clearly to the type of structure involved, but the data may be interpreted with more certainty when the reflexions are indexed and intensities measured and plotted in reciprocal space. By using a high-resolution pinhole camera, about a hundred and twenty separate reflexions were resolved in the fibre photograph. Intensities were measured using a microdensitometer. The values are preliminary.

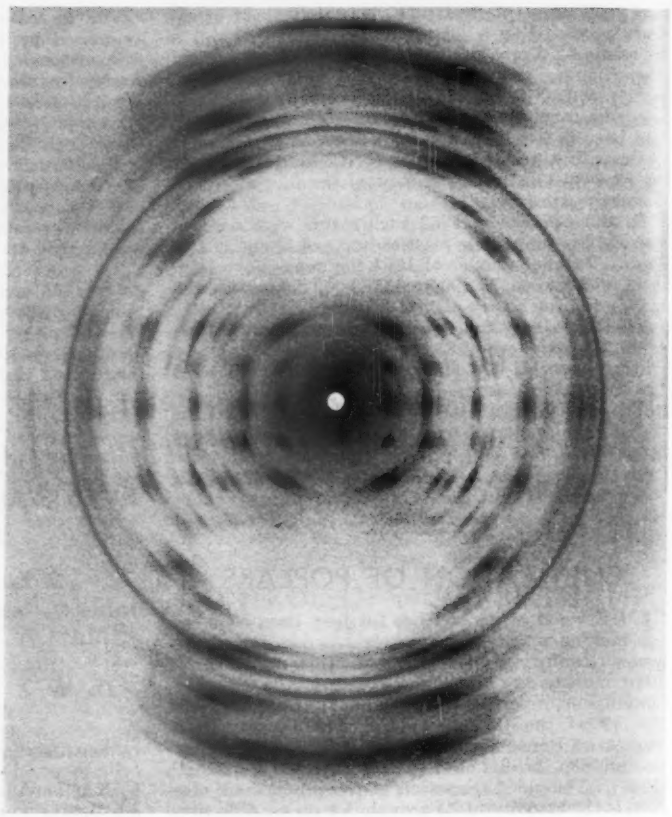


Fig. 1. X-ray diffraction photograph of a bundle of four fibres of crystalline mouse sarcoma deoxypentose nucleic acid (sodium salt) at approximately 75 per cent relative humidity. The ring is due to impurity. (Deoxypentose nucleic acid supplied by R. Barclay and L. D. Hamilton)

The unit cell of calf thymus deoxyribonucleic acid has been given[6] as face-centred monoclinic:

$a = 22{\cdot}0$ A. $b = 39{\cdot}8$ A. $c = 28{\cdot}1$ A. $\beta = 96\frac{1}{2}°$.

We find the values for mouse sarcoma deoxyribonucleic acid to be:

$a = 22{\cdot}2$ A. $b = 40{\cdot}4$ A. $c = 28{\cdot}1$ A. $\beta = 97{\cdot}1°$.

Deduction of the Main Features of the Structure

Fig. 2 shows a two-dimensional view of the intensities of reflexions plotted in reciprocal space. When reflexions overlap, the intensity is divided by the number of reciprocal lattice points possibly involved.

(*a*) *The structure is helical.* The pattern corresponds in striking fashion with the Fourier transform of a system of helices. The large empty trapezoidal space on and near the meridian strongly suggests a helix but could, however, also be given by alternative structures in which rods or sheets are inclined to the axis. These pseudo-helical structures can be distinguished, however, by the fact that they do not give several zeros of intensity on the layer lines, and the form function is not circularly symmetrical about the fibre axis. If paracrystalline deoxyribonucleic acid only were available, it would be impossible to establish the circular symmetry of the form function, and hence three-dimensional data obtained from study of the crystalline acid are necessary if the helical nature of the structure is to be proved. This is discussed later.

(*b*) *A major part of the helix has one sharply defined diameter.* The intensity distribution on the second layer line and on the outer parts of the equator alternates markedly between strong and weak and corresponds respectively with the functions J_2^2 and J_0^2 (squares of second- and zero-order Bessel functions). This diffraction would be produced by a helix of sharply defined diameter of about 18 A. The intensity on the 4th, 5th, 6th, 7th, 9th and 11th layer lines corresponds roughly to the main maxima of the functions J_7^2, J_6^2, J_5^2, J_4^2, J_3^2 and J_0^2 (Fig. 2), again for the same diameter of 18 A.

(*c*) *There are two coaxial* 18 *A. diameter helices spaced half a pitch-length apart.* The 1st and 3rd layer lines are weaker than the second, and the intensities correspond roughly with J_1^2 and J_3^2 (Fig. 2) respectively, for a helix of diameter approximately 10 A. The strong diffraction from 18 A. diameter helices observed on the 2nd layer line, but absent from 1st and 3rd, indicates that the structure contains two 18 A. diameter coaxial helices spaced apart along the fibre axis by about half the pitch-length of 28 A. (the layer line spacing) (see also ref. 8). The inner regions of the equator correspond to a

smaller average diameter than 18 A., and if the 10 A. helix extends over a range of diameter from about 9 to 14 A. it will contribute mainly to the inner regions of the equator and will not affect much the outer region, which corresponds to J_0^2 of 18 A. The equatorial intensity distribution will then be accounted for by the addition of the amplitudes diffracted by the 18 and 10 A. helices (Fig. 2). The 18 A. diameter helices do not contribute J_4^2 to the 4th layer line; hence the thickness of the 18 A. helix in the axial direction must be at least 3·5 A.

(*d*) *Spaced centrally between the two* 18 *A. diameter helices is one helix of mean diameter about* 10 *A.* We expect that the 10 A. helix may contribute to the intensity of the 2nd layer line. If this intensity followed accurately a J_2^2 function, the heights of the maxima first and second closest to the centre of the layer line would be in the ratio 1 : 0·4. In fact, these heights are about equal. If a small amplitude of J_3, corresponding to 10 A. diameter, is added *out of phase* to the 18 A. J_3, such an effect would be produced (Fig. 2). Hence we expect the 10 A. diameter helix to be spaced along the helix axis *halfway* between the two 18 A. diameter helices, the whole system being coaxial. This 10 A. diameter helix is apparently that part of the structure which Franklin and Gosling have remarked[8] is not repeated 14 A. apart along the fibre axis. Indications of this single helix can, in fact, be seen on their two-dimensional Patterson diagram.

(*e*) *There are eleven nucleotides per turn of one helix.* This is deduced from the fact that there is a system of Bessel function maxima converging on the centre of the 11th layer line (see also ref. 8).

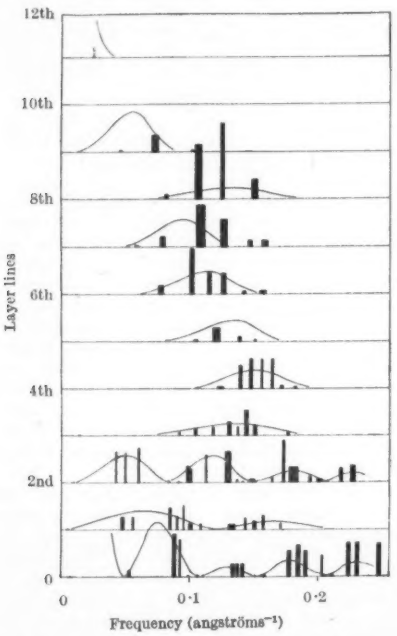


Fig. 2. Plot in reciprocal space of X-ray reflexions from crystalline deoxyribonucleic acid; fibre axis vertical. The height of each black rectangle is proportional to the observed form factor of the structure, and the area to the total intensity produced by overlapping reflexions. The continuous curve corresponds to the roughly calculated form factor for the helical structure suggested in the text

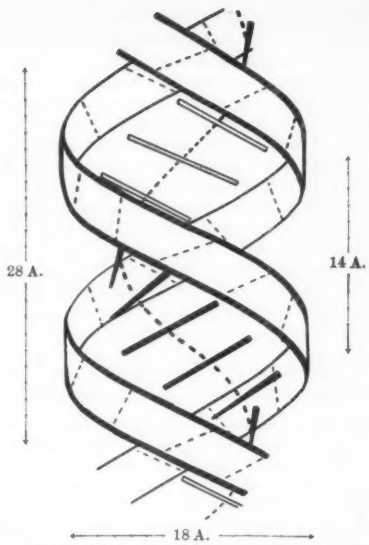


Fig. 3. The type of structure of the helical unit deduced from X-ray data of crystalline deoxyribonucleic acid. One helix of diameter approximately 10 A. is formed by a system of eleven inclined rods per turn of the helix. This helix is surrounded by two 18 A. diameter helices, each of which is also formed of eleven units per turn

(*f*) *The nucleotide shape resembles that of a rod inclined to the helix axis.* If the helical system is divided into nucleotides by planes at right angles to the helix axis, the intensities of the 10th, 9th and 8th layer lines would resemble that of the zero, 1st, 2nd and 3rd layer lines. In fact, this effect is observed in so far as the 18 A. diameter helix does contribute to the 9th layer line (though weakly) and is partly absent from the 10th. But it is anomalous that the 10 A. diameter helix does not contribute to the 10th layer line and the 18 A. helix does contribute, as J_4^2, to the 7th layer line. These effects would be explained if the nucleotides formed roughly a series of rods inclined at an angle of about 65° to the fibre axis in the opposite sense to the inclination of the helix. The X-rays are then reflected off these rods in a direction about 25° to the fibre axis. The 10 A. diameter helix, being in effect divided by inclined planes, diffracts very little energy along the meridian, and the 10th layer line is accordingly absent.

The structure of the helical system therefore begins to become clear and its probable form is shown diagrammatically in Fig. 3.

Circular Symmetry of the Form Function and the Elimination of Pseudo-Helical Structures

The fact that the form function, for example, on the 2nd layer line, alternates fairly smoothly between strong and very weak, indicates that it has circular symmetry about the fibre axis. Hence all pseudo-helical structures are eliminated. However, as the lattice is asymmetrical, a symmetrical form function is quite likely to produce general asymmetry of the intensity distribution. This effect, combined with some ambiguity of indexing, gave rise to the suggestion[5] that there might be a very definite asymmetry in the form function and therefore in the structure itself. If this were the case, the structure could not be helical unless the helix were considerably distorted. Probably the greatest asymmetry of reflected energy

is observed on the 2nd layer plane. There is a marked tendency for the h, k, $\bar{l}$ points to fall near maxima of the J_2^2 form function and h, k, l points to fall near minima and, as a result, the energy is reflected asymmetrically. There is, however, little reason to suggest that the form function deviates much from circular symmetry, and this applies on all layer planes. There are, however, a number of real discrepancies, mainly in regions of low intensity, which probably result from slight distortions of the helix. In particular, it appears that the helix, when viewed along the fibre axis, may not be quite round in section but elliptical. The eleven-fold nature of the structure also produces some asymmetry of the form function, but reliable data on this are not yet available.

Water Content of the Crystals and the Number of Polynucleotide Chains in the Helical System

The water content of crystalline calf deoxyribonucleic acid has been given[5,8] as approximately 40 per cent of dry weight. We find a value of about 45 per cent for *E. coli* deoxyribonucleic acid. Together with density measurements[5], the water content may be used to obtain the number of nucleotides per repeat unit in the crystal and, hence, the number of polynucleotide chains in the helical system. Deoxyribonucleic acid is very readily denatured, and it would be unwise to ignore the possibility that its fibres contain an appreciable fraction of degraded material which may not produce a distinct X-ray diffraction pattern. It was assumed[5] that such amorphous material would have a higher water content than the crystalline. We find, however, that specimens of deoxyribonucleic acid which have been degraded always have a lower water content than undenatured material, and this content may be as low as 10 per cent (cf. ref. 12). Hence we expect that the number of nucleotides per repeat unit calculated from water-content measurements will, if anything, be greater than the true value. Our measurements indicate twenty-two or less nucleotides per turn of the helical system (using density 1·47 gm. per c.c.[8]). There appears to be no doubt that there are two and not three polynucleotide chains in the helical system, each chain having eleven nucleotides per turn of the helix.

Molecular Model Building

We have built molecular models of the type described by Watson and Crick[7] and have adjusted them to conform with our experimental data. The result is promising: it appears likely that in the paracrystalline state[1,2,7] the pairs of bases lie on straight lines passing through the helix axis and at right angles to it, and the C_4 and C_5 atoms of the sugar are in the staggered position relative to each other. In the crystalline state the planes of the bases (as suggested[7]) are inclined to the helix axis and the C_4 and C_5 atoms of the sugar are in the eclipse position relative to each other. The whole of the phosphate and sugar groups then lies approximately at the same distance 9 A. from the helix axis and forms two 18 A. diameter helices spaced about 14 A. apart along the helix axis. The pairs of bases resemble rods inclined at about 65° to the helix axis (see above) and form a single helix of diameter 5–13 A. halfway between the two 18 A. helices. The model as a whole corresponds closely with the structure deduced from X-ray data, and calculation of the diffraction pattern from the model is in progress. One objection to the structure might be that if eleven nucleotides are arranged on one turn of each helix, some of the interatomic distances between different atoms in the same phosphate-ester chain, for example, O—O, C—O, are less (about 2·7 A.) than usual Van der Waals distances. But as such small distances are found in peptide chains[13], this objection is probably not serious.

We wish to thank Prof. J. T. Randall for advice and encouragement; Dr. J. D. Watson and Mr. F. H. C. Crick, Miss R. E. Franklin, Mr. R. G. Gosling and Dr. G. L. Brown for discussion; Drs. L. D. Hamilton, R. Barclay, J. Rowen, H. Ephrussi, G. L. Brown and Prof. R. Signer for specimens, and Miss P. M. Cowan for advice on model building. One of us (H. R. W.) acknowledges award of a University of Wales Fellowship, and another (W. E. S.) a grant from the British Empire Cancer Campaign.

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CORRELATION OF PLIOCENE AND PLEISTOCENE MARINE BEDS

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THE theory of glacial control, by which Pleistocene changes of sea-level are believed to reflect changes in the volume of the earth's ice-sheets, has been widely accepted; but it is not always realized that it depends on the idea that eustatic changes of sea-level have taken place, the proof of which depends on the accurate dating and correlation of raised beaches over great distances. This point was emphasized by Daly many years ago[1]. In particular, Deperet[2] tried to correlate some British raised beaches with the classical series in the Mediterranean, and I have made recently a fresh attempt, summarized here, to correlate British and Mediterranean marine beds, using the Mollusca as zonal fossils.

Ever since the time of Lyell, it has been realized that the earlier marine deposits of the Pliocene–Pleistocene series contain more extinct shells than the later beds, and Gignoux[3], among others, proved a gradual reduction in the extinct Mollusca of the Mediterranean area as the sequence is followed up from the Astian through the Calabrian to the Sicilian and Tyrrhenian beaches. In the British area, a similar progressive disappearance of extinct shells can be traced from the Coralline Crag through the Red Crag and the Icenian to the raised beaches and shell-beds of the Glacial Series, as is well known from the work of Wood[4], Harmer[5], Bell[6] and others.

This similarity between the two areas suggests a basis for general correlation, but it is difficult to equate the individual stages by this method alone.

In my own investigations I have found that the presence or absence of certain extinct species is important in subdividing the post-Icenian shell-beds of Britain, a point which I did not realize in my earliest work[7]. The oldest beds in the Drift are now known to contain such extinct forms as *Panopaea faujasii* and *Voluta lamberti* (in Norfolk and Aberdeenshire), species which are unknown in younger glacial beds. At a later glacial stage, a few extinct shells still survive, including *Nucula cobboldiae*, *Tellina obliqua*, *Purpura incrassata* and *Nassa reticosa*, as in the Corton Beds (East Anglia)[8], Yorkshire, Aberdeenshire, the Isle of Man, the Wexford Gravels of south-east Ireland and at Selsey (Sussex). In some of these areas the marine material is glacially transported, but its molluscan assemblage remains recognizable. In such 'late-glacial' beds as the Torbay and Portland raised beaches[9], the March Gravels (Fenland)[10], the Kelsey Hill Beds (Yorkshire), the Clyde Beds of Scotland and Ireland, and in much derived material in North Wales, Lancashire, Cheshire and Shropshire, the extinct shells have disappeared almost entirely. Finally, the still later Holocene beds of Scotland and Ireland contain no extinct species at all.

These facts were discovered by making as complete a catalogue as possible of all the species occurring in the Pliocene–Pleistocene series, and this investigation has also brought to light some very important facts about the past changes in the climatic belts as shown by the distribution of some of the fossils. Gignoux[3] and others have shown that the warm conditions of Astian time in the Mediterranean area gave place to increasing cold (with fluctuations) during the Calabrian and Sicilian, but that a warm fauna returned during the Tyrrhenian stage. Now it is most significant that an exactly similar climatic sequence is found in Britain, where the warm fauna of the Coralline Crag gave place to increasing cold during the Red and Icenian Crags, followed by a partial return of warm forms during the Corton stage[8] (in East Anglia, Yorkshire, Aberdeenshire, the Isle of Man, Wexford and Sussex). This climatic sequence, considered with the method based on extinctions, suggests the correlation shown in the accompanying table, the partial return to warm conditions in the Tyrrhenian and Cortonian being especially important.

Mediterranean	Britain
Holocene	Holocene
Monastirian	Portland raised beach, March Gravels, Clyde Beds, etc.
Tyrrhenian	Selsey Beds, Corton Beds, Wexford Gravel, etc.
Sicilian	Early Glacial, Cromer Till
(Erosion)	(Cromer Forest Bed)
Calabrian	Icenian Crag, Red Crag
Astian	Coralline Crag

It was found in practice that there are discrepancies in detail between the sequence in Britain and that in the Mediterranean; but these can be eliminated by assuming that the temperature gradient in the eastern Atlantic was steeper in Pliocene and Pleistocene times than it is to-day. This assumption helps to explain the mixture of warm and cold indicators found in the Crags and in the Calabrian, and also in some deposits investigated by me in Lewis[11] and in East Anglia[8]. This steeper temperature gradient would enable the cold 'Scandinavian' species and the warm 'Lusitanian' forms to live nearer together than they do to-day, and even to intermingle. This assumption also explains why it is possible to find mainly warm indicators in certain Mediterranean raised beaches, contemporaneous with a mixed warm and cold assemblage in England and chiefly cold indicators in the Scottish Clyde Beds, all dated as Monastirian.

These two methods of correlation based on extinction and on the reconstruction of the climatic belts of the past are strongly supported by a detailed study of the evolution of certain groups of Mollusca, and give the same correlations. For example, *Pecten islandicus* evolved from its Icenian ancestor at the same time that *Panopaea faujasii* was becoming extinct both in the Sicilian of the Mediterranean area and in the earliest glacial beds in Britain. An example of evolution within one group is seen in *Turritella : Turritella tricarinata* is common in the Astian and in the Coralline Crag, and evolved through Calabrian and Red Crag times into *Turritella communis*, which becomes the common form of this group at the close of the Calabrian – Red Crag stage. A comparison of certain Nassas of the two areas gives similar results : *Nassa pygmaea* seems to have evolved from *Nassa incrassata* during the Calabrian and Red Crag ; and *Nassa reticulata* first appears in its modern form in the Tyrrhenian and Cortonian, having evolved from the Calabrian – Red Crag extinct species *Nassa musiva*. Several other shells, such as *Venus fasciata* and *Neptunea contraria*, show similar use in dating, but are not yet worked out in detail. These three methods based on extinction, climatic distribution and evolution agree in the correlation shown in the table.

It is hoped that the evidence for the correlations suggested here will soon be published in greater detail. They differ somewhat from those proposed recently by King and Oakley[12] and by Zeuner[13], but agree better with Lagaaij's conclusions based on the Bryozoa[14]. These marine horizons should prove useful in the future as a basis for correlating certain non-marine deposits (plant beds, fluviatile, volcanic and glacial), including some containing Palæolithic implements, and there is already good evidence to show that this will be a valuable outcome of this investigation.

There is also clear proof that the heights of at least the Tyrrhenian and Monastirian beaches (dated palæontologically) correspond well for Britain and the Mediterranean. So far as this evidence goes, it confirms the idea that eustatic changes of sea-level have really taken place, and therefore it helps to support one of the foundations of the glacial control theory : but it is most important to realize that the changes of climate reflected in the various marine fauna suggest that it is improbable that glacial control was the only, or even the most important, factor in determining changes of sea-level. [May 22.

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LETTERS TO THE EDITORS

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Indolepyruvic Acid in Maize

The several reports of the presence of indole acetaldehyde in plants (reviewed by Larsen[1]), coupled with the recent isolation of indoleacetonitrile from cabbage[2], suggest that numerous indole derivatives related to indole-acetic acid may be of natural occurrence. The importance of such substances as precursors or breakdown products of the natural auxin needs no elaboration. It was therefore thought worth while to make an extensive investigation of the indole derivatives occurring in plant materials.

For this purpose chromatographic methods have been developed with the view of their general applicability to the largest possible number of compounds. The solvent mixtures used by Jerchel and Müller[3], Wolf[4], and Yamaki and Nakamura[5], though suitable for the special separations studied by these workers, were not found applicable to the wide range of indole derivatives included in this study. Accordingly, a systematic investigation of different solvent mixtures was undertaken, comparing various common organic solvents, and leading to a more detailed study of the aliphatic alcohols and of the effect of the water content of the mixtures. The effects of *p*H were also studied, and ammoniacal conditions were adopted for separation of the acidic substances. These experiments led to the selection of *iso*propanol : 28 per cent aqueous ammonia : water in the ratio of 8 : 1 : 1 by volume as giving the best overall separation of the compounds. A similar choice of solvent has been reported by Bennet-Clark *et al.*[6] (cf. also Luckwill[7]).

The ascending technique with Whatman's No. 1 filter paper was used. The ionic compounds were found to give the best spots. For colour development, the following four reagents were found most generally suitable: the Salkowski and Ehrlich reagents, diazotized sulphanilic acid and diazotized *p*-nitroaniline. By selection of reagent and by taking advantage of the effects of *p*H, about thirty indole derivatives could be separated and identified. Of these, ten, including indole and skatole, tryptophane, tryptamine, hypaphorine, gramine, abrine, indole-acetic acid and its ethyl ester, and indoleacetonitrile, are known to occur in plants.

The method has been applied to the indole derivatives of maize endosperm (variety Country Gentleman). Extraction was by a modification of the method of Berger and Avery[8] but under conditions precluding bacterial attack, and minimizing oxidation of the extracts. It was found that along with indole-acetic acid there was present a second acid substance, of lower R_F, giving a pink colour with the Salkowski reagent. Both spots were prominent and distinctly separate. When the R_F of indole-acetic acid was 0·25, that of this second compound was 0·12. On extraction from the paper, this lower substance was found active in promoting the growth of *Avena* coleoptile sections and in causing curvature of slit pea stems. Comparison of the R_F and colour reactions with those of authentic samples (prepared by two methods[9,10]) identified this compound as indole-3-pyruvic acid. This has been previously shown to have auxin activity[11] but has not been demonstrated

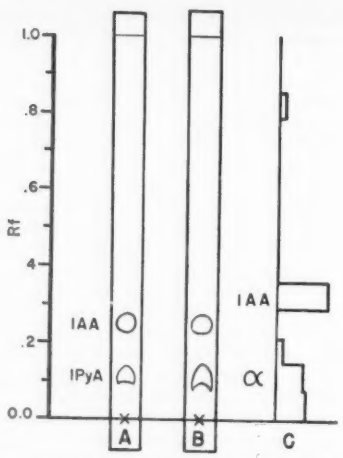

Fig. 1. *A*, Representation of the chromatogram obtained from synthetic samples of indole acetic acid (IAA) and indole-pyruvic acid (IPyA) and sprayed with the Salkowski reagent. *B*, Chromatogram of maize extract run under the same conditions. *X* is the origin in both cases. *C* is adapted from Bennet-Clark and Kefford's Fig. 1(*A*), ref. 12, where the bars represent the relative activity in coleoptile extension, above that of controls, of sections cut from chromatograms of etiolated broad bean shoot extract. Only those sections showing growth promotion are given here. The scale of the graph, and the solvent used, are essentially the same as in ours, but they employed the descending technique

to occur in plants, although its occurrence as an intermediate between tryptophane and indole-acetic acid has been suggested (see ref. 1).

Bioassays by Bennet-Clark[12], Lexander[13], and Terpstra[14] have indicated the presence in several plant extracts of an auxin having similar R_F values. This has been called accelerator α[12], substance a[13], and the IAA 'tail'[14]; but in the light of our experience, it seems likely that all of these refer to indole-3-pyruvic acid (see Fig. 1). Both the synthetic compound and that present in maize extracts break down under very mild conditions to yield some indole-acetic acid, which was readily identified on the chromatograms.

A detailed description of these experiments will be published elsewhere. One of us (B. B. S.) is working under a predoctoral fellowship in the biological sciences granted by the United States Atomic Energy Commission.

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Promotion of Infection by Intravenously Administered Polysaccharides

A VARIETY of polysaccharides shows infection-promoting activity[1–4]. Nungester, Wolf and Jourdonais[1] noted that a crude gastric mucin preparation greatly lowered the minimum lethal dose of bacteria when the mucin together with the bacteria was given intraperitoneally, although it did not lower the minimum lethal dose sensibly when the mucin and the bacteria were given intravenously. This observation appears to be the basis of a belief that the infection-promoting activity is conditional upon the injection of the polysaccharide into a serous cavity[5]. The question whether a peritoneal infection can be promoted by a polysaccharide injected into the blood stream does not appear to have been examined critically. Since a number of polysaccharides are of interest as plasma volume expanders, this question might have clinical implications.

Infection-promoting potencies of dextran, levan, and mucin have been studied in mice given *Salmonella typhi*, 0·901, intraperitoneally. When mice (16–20 gm.) received intraperitoneally 0·1 minimum lethal dose of the bacteria, the mortality-rate was less than 5 per cent. When at the same time the mice also received 5 mgm. of native dextran or native levan, either intraperitoneally or intravenously, the infection was strongly promoted (mortality-rates greater than 70 per cent). Mucin, though similarly active when given intraperitoneally, was without activity when given intravenously. The peritoneum exudate was found to remain levan-free even after a massive dose (30 mgm.) of native levan had been injected intravenously.

It is evident from these results that the promotion of infection by the neutral bacterial polysaccharides given intravenously does not require the local enclosure of the bacteria in the peritoneal space by an envelope of viscous polysaccharide. Whereas the neutral polysaccharides given intravenously appear to exert their influence on an extravascular infection, it need not be postulated that the host-component inhibited by the polysaccharides is necessarily specifically extravascular. The levan failed to exert a decisive effect on intravenously inoculated bacteria. Hence it must fail to suppress at least one of the effective systemic anti-bacterial principles. As to dextran, Smith *et al.*[3] have shown that it is without anti-complementary activity. We have found that, like mucin, native levan is lacking in infection-promoting activity when it is administered into the peritoneum of a mouse which has received an irritant (namely, a sub-lethal dose of bacteria) intraperitoneally 15 hours previously. This suggests that levan does not suppress the phagocytic activity of leucocytes which have gathered in the peritoneum in the course of the inflammatory process. In the light of these observations, it is perhaps permissible to speculate that the neutral polysaccharides, native dextran and native levan, are promoters of infection in the normal mouse because they modify the inflammatory process, with the result that transport of an anti-bacterial agent into the peritoneal space is restricted[6–8].

Since infection-promoting activity is clearly undesirable in a clinical plasma-volume expander, it has been reassuring to find that acid hydrolysis leads to a rapid attenuation of the activity of both levan and dextran. Whereas the native levan and the native dextran with a molecular weight greater than 10^6 were both highly active as infection-promoters, the homologues with molecular weight in the range 10^4–10^5 recovered from a partial acid hydrolysate of levan or dextran manifested a negligible infection-promoting activity when given either intravenously or intraperitoneally.

The high potency of the neutral native bacterial polysaccharides (native levan, native dextran), their ready availability, adequate solubility, simple constitution, and homogeneous condition suggest that their use as promoters of infection in the place of the currently employed hog gastric mucin may offer worthwhile advantages. Since these neutral polysaccharides given intravenously are able to promote an extravascular infection, the latter is available in a form in which its responses to an antibiotic can be tested in the absence of an interfering viscous vehicle at the site of the infection. Furthermore, it may be anticipated that the range of action of the intravenously effective promoters will not be limited to peritoneally produced infections, but will also extend to infections produced at other vascularized sites.

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Heteropycnosis in the Autosome Segments of *Ceriagrion coromandelianum* (Odonata)

THE sex-determining mechanism in dragon-flies consists, as a rule, of *XO*—*XX* chromosomes, and the *X*-chromosome in the spermatocyte divides equationally in the first, and passes undivided to one pole or the other in the second, meiotic division[1–4]. In this respect, the *X*-chromosome of the male germ-cell in the Odonata behaves as in the Heteroptera, in which group also it usually divides in the first meiotic division only. We find that the chromosomes of the damsel-fly, *Ceriagrion coromandelianum*, exhibit another important feature in respect of which they resemble the hemipteran chromosomes; that feature is the presence of Feulgen-positive interconnecting threads joining the chromosomes at the spermatogonial metaphase, and also at the first and second meiotic metaphase. Such interconnecting chromatic threads are known to exist in many hemipterans[5–8]. Associated with the presence of these threads is a high degree of heteropycnosis of autosome segments. At pachytene the paired chromosomes carry deeply stained, condensed knobs. These heterochromatic segments occur in all chromosome pairs. The interconnecting threads, in our opinion, are derived from the chromosome matrix. It is well known that the protein framework of the heterochromatic chromosomes (or chromosome segments) differs from that of euchromatic chromosomes[9]. It is likely that

the nucleoprotein matrix synthesized by these segments is cohesive[7] and that any fortuitous contact and subsequent separation between chromosomes result in the drawing out of the matrix substance into fine threads.

Another point of resemblance between the chromosomes of Odonata and Hemiptera might be considered to have been furnished by the discovery, apparently, of *m*-chromosomes in several dragon-flies[1,3,4]. These elements have been held to correspond to the *m*-chromosomes of Coreidæ (Hemiptera). Our own observation of the chromosomes of *C. coromandelianum* has, however, convinced us that there is scarcely any justification for naming the smallest pair of chromosomes of this organism as *m*-chromosomes, as Chaudhuri and Gupta[4] have done. The *m*-chromosomes of Coreidæ are characterized by non-association during meiotic prophase, whereas the smallest chromosome pair of *C. coromandelianum* pair regularly. The so-called *m*-chromosomes, like the other elements, in this organism are found completely paired during pachytene; at diplotene and diakinesis also they are not distinguishable from the others in this respect. It seems, therefore, preferable not to name the small chromosomes of *C. coromandelianum* as *m*-chromosomes. As White[10] holds, this term should be applied to chromosomes showing the anomalous behaviour characteristic of the *m*-chromosomes of Coreidæ—a condition not fulfilled by any chromosomes in the Odonata.

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Regular Occurrence of the Haploid Number of Chromosomes in Mesenchymal Cells of the Tail Tip of *Rana pipiens* Tadpoles

The recent report by Lindahl[1] that the micromeres in certain sea urchins give rise to cells which contain the haploid number of chromosomes has far-reaching implications. Since the mesenchymal cells are the principal derivatives of the micromeres, it now seems pertinent to examine the chromosome numbers in such cells in animals of different groups.

In whole mounts of tail tips from normal tadpoles of *Rana pipiens*, a conspicuous feature is the discrepancy in size between the cells and nuclei of the epithelial covering and those of the connective tissue. Camera lucida projections of nuclei in the two layers give areas for the mesenchyme nuclei one-half those of epidermal nuclei (ratio $0{\cdot}45 \pm 0{\cdot}08$). The depths of the nuclei as measured by focusing are about the same, thus giving a twofold difference in nuclear volume.

Table 1. Numbers of Cells with Given Numbers of Chromosomes

Type of cell	Numbers of chromosomes				
	26	21–25	13	10–12	>13
Epidermal	10	6	—	—	—
Mesenchymal	—	—	21	13	3

A preliminary survey of the literature does not reveal any chromosome counts in these tissues. This is not surprising, since the mitotic figures, after the standard methods of fixation, are difficult to analyse. The chromosomes are small and usually closely packed. For the present study, in addition to tail tips fixed within a minute or two after cutting, tips were at hand which, following a suggestion of Fankhauser[2], had been allowed to stand in spring water for 30–60 min. prior to fixation. By this treatment the chromosomes are spread apart in a manner similar to that recently described by Hsu[3] for human cells in tissue culture. In epidermal cells in the tips of treated tails, the chromosomes at metaphase are beautifully separated in a flat plate. In mesenchymal cells, the majority of figures resemble pro-metaphases, with chromosomes sufficiently discrete to allow counting by careful focusing. The use of whole mounts makes possible the analysis of intact cells the position of which has not been disturbed. The tips were fixed in Smith's formalin–dichromate–acetic mixture, stained with Galligher's hæmatoxylin and fast green and mounted whole in 'Clarite'.

The results of the counts for epidermal and mesenchymal nuclei are given in Table 1. From tadpoles of three clutches, nine normal and six regenerating tips were examined, the latter because of their abundant mitoses. It was possible to count a few figures in tips that were not treated with spring water. No differences in chromosome numbers were found in treated and untreated tips. Sample divisions in epidermal cells of each tip showed exactly 26 chromosomes in most instances—that is, the diploid number for *Rana pipiens* (Briggs[4]). In mesenchymal cells, 21 out of 37 mitoses showed exactly 13 chromosomes, while less clear cases gave 10–12. A few anaphase and telophase figures contained 13 chromosomes in each daughter group. Areas of these mitoses drawn with the camera lucida were about one-half those of the comparable epidermal divisions. Endothelial cells and chromatophores gave some counts that were close to 13 and others that were higher but could not be seen to be 26.

Nuclei with two nucleoli are not uncommon among the mesenchymal cells. These nuclei are larger than the average. Sometimes a single cell contains two nuclei, each with a single nucleolus. Whether there is occasional restoration of the diploid condition or whether the diploid state only precedes the haploid is not yet clear. In one mesenchymal cell with more than 13 chromosomes, homologues lay noticeably paired. This may represent either a precursor of, or a sequel to, a reduction division.

Whether the haploid chromosome complement appears in cells of mesodermal origin in other organs in the frog remains to be determined. Parmenter[5] reports the diploid number in cells of the peritoneum. The frequent occurrence of 13 chromosomes in mesenchymal cells in the tail of *Rana pipiens* suggests the possibility of a somatic reduction in chromosome

number at some earlier stage in development, at least in the tail. It is hoped that further analysis will show at what time this form of nuclear differentiation takes place.

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Listeria Infection in the Guinea Pig caused by Feeding with Aureomycin

The toxicity of aureomycin to guinea pigs, reported earlier by one of us[1], has been further investigated, a part of the results having been published elsewhere[2]. Since it was found that aureomycin is far more toxic to guinea pigs when administered orally than by subcutaneous injection, it was concluded that this specific action of the drug must be primarily connected with the processes taking place in the digestive tract. Attention was therefore directed to the changes in the composition of the intestinal flora arising from the oral administration of aureomycin.

Cæcal samples of the animals were inoculated in different media and the types of micro-organisms found in the largest numbers were isolated. Distinct differences in the cæcal flora between the aureomycin group and the control group could be established as early as 24 hr. after the beginning of the experiments. A striking feature in the aureomycin group was the abundance of an organism belonging to the family Corynebacteriaceæ, genus *Listeria* (*Listerella*). The same bacteria, together with anaerobic sarcina (cf. ref. 3) and aerobic, spore-forming rods, were found by direct microscopic examination to dominate in the cæcal samples of aureomycin-animals. Cells of *Oscillospira*, *Fusobacterium*, *Spirochaeta*[4] and *Borrelia*, abundantly present in the control animals, had almost disappeared in the aureomycin-fed animals, and the number of lactobacilli and yeasts was greatly reduced.

Testing *in vitro* the activity of different antibiotics on the isolated cultures of *Listeria* showed that the organism tolerates rather high concentrations of aureomycin but is more susceptible to penicillin and chloromycetin. Accordingly, it should be possible to prevent or cure the toxic effects of aureomycin by administration of penicillin or chloromycetin. Experiments showed that this could indeed be done. Most of the guinea pigs which had been kept on a diet containing penicillin or chloromycetin previous to the feeding of aureomycin did not develop symptoms of toxicity at all or showed them only transiently. In some cases it was also possible to stop the loss of weight and cure the 'disease' already started by oral administration of penicillin or chloromycetin, or to prevent the development of the disease by administering penicillin or chloromycetin simultaneously with aureomycin right from the beginning of the experiment[2].

The toxic symptoms in the aureomycin-fed animals included a distended belly, pale-grey focal necroses in the liver, and red infarcts in the lungs. These symptoms are in good agreement with those given in the literature[5] for *Listeria* infection. Similar changes leading to death in one week developed when healthy animals were injected intraperitoneally with the isolated *Listeria* cultures. The spleen, however, which in the aureomycin-fed animals had decreased in size and was of a pale pink colour, was in this case large and dark purple, an observation made earlier with rabbits injected with *Listeria* cultures[5].

The results obtained indicate that the toxicity of aureomycin for guinea pigs is evidently due to an unfavourable change in the intestinal flora. By suppressing certain strains of bacteria, aureomycin permits the active growth of other organisms which normally play only a subordinate part in the intestinal flora. One of these bacteria, *Listeria*, is harmful to the guinea pig, causing typical symptoms of toxicity and leading in most cases to the death of the animal.

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Fertilizing Capacity of Frozen Human Spermatozoa

Montegazza[1] observed the survival of human spermatozoa after exposure to a temperature of − 15° C. He speculated that in the future, frozen semen might be used in animal husbandry and even proposed that a man dying on the battlefield might, by his wife, beget a legitimate child after his own death. Other workers[2] have reported the survival of human spermatozoa; however, it was not until Polge, Smith and Parkes[3] reported increased survival of frozen human spermatozoa employing glycerol as a protective agent that practical application seemed possible. Work in our laboratory[4], recently, indicated that treatment with 10 per cent glycerol prior to freezing with 'dry ice' produced an average 67 per cent survival of human spermatozoa obtained from five young healthy men.

Parkes[5] has succinctly stated the problem of the frozen-thawed human spermatozoon: "A much more important and doubtful point is whether vitrification affects the power of the spermatozoon to fertilize and activate the egg and induce normal embryonic development". The following observations have been made on fertilization and activation of the egg.

Three recipients have been successfully inseminated with frozen semen: one woman, nulliparous, has missed six menstrual periods, has cervical softening and uterine enlargement, and has developed other presumptive signs of pregnancy. The second woman, primiparous, has subjective signs of pregnancy, and one week after her first missed menses the Aschheim – Zondek test was suggestive; following an additional seven days of observation the test became positive. Five menses have not occurred. An X-ray film shows a normal developing fœtal skeleton. The third

recipient, nulliparous, has missed three menses and the Aschheim–Zondek test is positive.

The personal histories of the three recipients indicate a high degree of integrity and the source of the conceptions is valid.

The ability of glycerol-treated, frozen and thawed human spermatozoon to fertilize and actuate the human ovum has been observed. General clinical application of this fact must wait until normal embryonic development has been observed and the progeny are declared normal.

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Thoracic Glands of *Iphita limbata* Stal.

The thoracic gland has been shown in a number of insects to be the immediate source of the moulting hormone. It has been demonstrated recently that the neurosecretory cells of the brain activate the thoracic gland and thus bring about moulting.

The thoracic glands in a number of insect groups still await discovery. Scharrer[1] suggests that the 'tracheal organs' in *Nepa* probably represent the thoracic glands; Williams[2] cites the presence of thoracic glands in *Oncopeltis*. Wigglesworth[3] describes in detail the thoracic gland in *Rhodnius*, which is the only complete account of the glands in the Hemiptera; he also points out that the 'tracheal organs' in *Nepa* reach their full development in the adult, while separate thoracic glands are present in nymphal instars which disappear in the adult. Prof. Wigglesworth (*in litt.*) informs me that a comparative study of thoracic glands in Hemiptera is being done in his Department by Mr. M. J. Wells.

In *Iphita limbata* Stal. (Pyrhocoridæ : Hemiptera) the thoracic glands have been found in the last two nymphal instars as well-defined structures, associated with the inner lobe of the thoracic fat body. The gland on each side consists of a loose collection of large cells with conspicuous chromatin and secretion product, lying along the periphery of the inner lobe of the fat body, which is well tracheated. Under the ordinary microscope they are not visible unless stained, but they could easily be seen and studied under the phase-contrast microscope. Fig. 1 shows the cells of the gland under the phase-contrast microscope. These cells remain more or less in contact and show an irregular shape and lobed nuclei. They appear yellowish under the phase-contrast optical system.

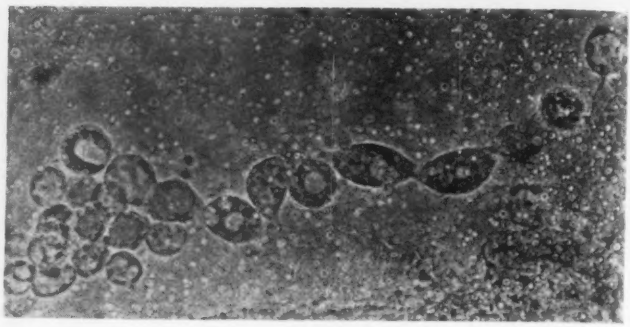

Fig. 1

The study of the structure and physiology of these cells is being continued.

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Biogenesis of Nicotine

Following the demonstration that the amino-acid tryptophane can readily be converted by barley plants into the alkaloid gramine[1], the study of the biogenesis of alkaloids carried on here has included investigations into the possibility that nicotine may arise from tryptophane in a manner similar to the formation of nicotinic acid in animals and micro-organisms[2]. Recent discussions of this possibility[3,4] prompt me to describe part of these investigations.

DL-Tryptophan, containing carbon-14 in the β-position, was fed, in the form of its acetate, to young tobacco plants *via* the roots. The leaves, which became radioactive, were dried, digested with 40 per cent sodium hydroxide solution, steam-distilled and the volatile bases isolated as hydrochlorides. By chromatography on Whatman No. 1 paper using *n*-butanol/hydrochloric acid[5] as a solvent and developing upwards, the nicotine from the plant was separated from other products, its position (R_F 0·2 at 20°) being located by the bismuth nitrate/potassium iodide reagent[5].

The nicotine spots so obtained were found to exhibit no radioactivity measurable by a thin-window counter. The results so far obtained lend no support to the theory that the tryptophane molecule *in toto* is converted into nicotine, although the possibility that the pyridine ring is formed from the indole moiety is not excluded. Further investigations into the problem are in progress.

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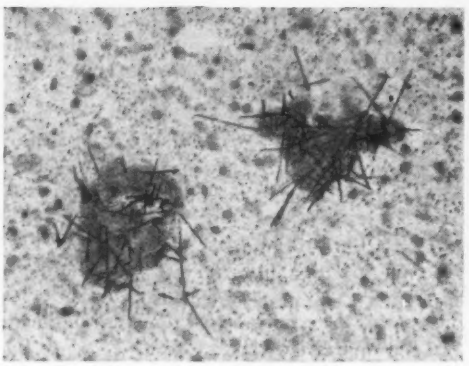
Tissue Dosage from Thorotrast in the Body

During the past twenty-five years a large number of people have been injected with thorotrast for radiographic purposes. Thorotrast is a colloidal solution of thorium oxide which, after injection, is rapidly taken up by the reticulo-endothelial system, particularly the liver and spleen, where the thorium remains practically indefinitely, and only some of its products may be excreted. In the course of time the action of the radiations may give rise to certain clinical symptoms[1], and this fact offers an opportunity for studying the correlation between the clinical effects of radiations and the dosage delivered to tissue. The amount of thorotrast in the given organ is often estimated from a measurement of the γ-ray activity, mainly due to thorium-C″, observed with a Geiger–Müller or scintillation counter[2]. Since, however, more than 90 per cent of the total energy dissipated in tissue is carried by the α-particles, which have a very short range, it is clear that a quantitative study of the radiation dosage requires a technique employing microscopic analysis. Furthermore, it is known[3] that thorotrast in the body forms aggregates of size similar to, or even greater than, the range of the α-particles; some of the energy of the α-particles is thus absorbed in the thorotrast itself, and in order to determine the energy dissipated in tissue this self-absorption has to be taken into account.

We have studied this problem by using the technique of α-track autoradiography. Histological sections, 3–10 μ thick, from organs containing thorotrast were obtained and used to prepare autoradiographs by means of Ilford *C*.2 nuclear emulsions. Two methods were employed: in one, liquid emulsion was used; it was poured on to the mounted sections to a thickness of 50–100 μ and then dried quickly. In the second method, *C*.2 plates were placed directly in contact with the sections and exposed under light pressure to ensure intimate contact. After the required period of exposure the sections were processed in the usual way and the α-particles observed through a microscope.

In order to calculate the tissue dosage it is necessary to determine the radioactive content of the section, that is, the activity of thorium and of each of its α-emitting products contained per unit volume of tissue. If the section were infinitely thin the various radioactive substances could be easily identified by the length of the α-particle tracks in the emulsion. With a section of finite thickness the length of track observed in the emulsion is shorter than the true range; even a single radioactive isotope in the section gives a continuous distribution of track lengths, from zero to the full range. The shape of this distribution curve can, however, easily be calculated. The measurement of the lengths of the tracks from a given area of the section thus makes it possible to determine the radioactive content of the section. Furthermore, by comparing the relative amounts of radiothorium and thorium in the section with those in the thorotrast itself, it is possible to deduce what the radioactive content was in the organ *in vivo*.

The next quantity necessary for the determination of tissue dosage is the fraction of the total energy of the α-particles dissipated outside the aggregates from which they were emitted. This can be calculated from a measurement of the areas of the aggregates in the sections by means of a square eye-piece graticule. The thorotrast shows up as yellow granular deposits against the blue-stained cell nuclei; the accompanying photomicrograph shows the appearance of some large aggregates, together with α-particle tracks recorded in the emulsion. From the observed distribution of aggregate sizes it is possible to calculate the fraction of the total energy, F, from all α-emitting substances, dissipated in tissue.



Photomicrograph of liver section showing large thorotrast aggregates with α-particle tracks

The average tissue dosage is given by the expression $D = NF\bar{E}$, where N is the total activity of the organ, that is, the total number of disintegrations per unit time, per unit volume of tissue, and $\bar{E}$ is the 'effective energy' of the α-particles, which is related to the radioactive content of the organ.

The accompanying table gives an example of the results of such calculations of tissue dosage. All figures refer to one patient, who was given an injection of 22 ml. of thorotrast in 1938. A splenectomy was performed in 1949 and biopsy samples from several other organs were taken at the same time; the autoradiographs were prepared in 1951.

Tissue Dosage to Various Organs

Section	Disintegrations per min. per mm.³ of tissue N	Percentage of energy dissipated in tissue F	Effective energy of α-particles $\bar{E}$ (MeV.)	Energy dissipated in tissue per min. per mm.³ of tissue D (MeV.)	Tissue dosage (rep. per week)
Spleen (interior portion)	260	1·8	5·33	24·9	4·8
Spleen (exterior portion)	28·2	26·5	5·68	42·5	8·3
Hilum of spleen	12·3	29·2	5·05	18·1	3·5
Liver	12·8	56·3	5·80	41·8	8·1
Lymph-node	1·45	81·0	5·33	6·2	1·2
Tonsil	0·49	66·6	5·88	1·9	0·4

The figures in the last column of the table give the tissue dosage in rep. per week. In the organs which took up most of the thorotrast, the spleen and liver, the tissue dosage was of the order of 8 rep. per week. Assuming a relative biological efficiency of 20 for α-particles[4], this corresponds to about 160 röntgens of X-rays per week. The accepted value of the tolerance dose for whole-body irradiation is 0·3 r. per week[4].

If all the products of thorium remained in the organ and if the thorotrast were mixed homogeneously with tissue, the tissue dosage to the spleen of the patient referred to in the table would be expected

to be about 40 rep. per week. The greatly reduced dosage-rate actually observed is partly due to an escape of some products from the organs but mostly to the formation of the aggregates with the resulting self-absorption of the α-particles. As a consequence of this absorption the tissue dosage is not proportional to the concentration of thorotrast in the organ. This can be seen clearly when comparing the values in columns 2 and 6 of the table. While the total activity of the various organs, which roughly corresponds to the amount of thorotrast in them, varies by a factor of 500, the tissue dosage delivered to these organs varies only by a factor of about 20. The process in the body which produces the aggregates, probably of a physico-chemical nature, acts thus as a kind of compensating mechanism which results in a reduction of the radiation delivered to tissue.

The tissue dosage shown in the table represents average values for the given organ. Actually, within each organ the dosage is distributed non-uniformly. In most organs the distribution of the thorotrast aggregates shows the presence of a large number of small aggregates, of radii about 5 μ, and a very small number of large aggregates. These few large aggregates contain a considerable proportion of the thorotrast in the organ, and despite the self-absorption they produce a very intense tissue dosage in their immediate neighbourhood. On the other hand, the numerous small aggregates produce a uniform dosage to the whole organ, which is several times lower than the average value. The dosage delivered to tissue consists, therefore, of a uniform radiation of the order of 0·3–0·8 rep. per week, with a few hot spots in which the dosage may be fifty or even a hundred times higher. The significance of these results on the occurrence of clinical symptoms of radiation damage has yet to be established.

Our thanks are due to Dr. O. M. Henriques, director of the Finsen Laboratory, Copenhagen, for sending us the sections, and to the Medical Research Council for a grant which enabled this work to be carried out.

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Origin of the Absorption Band at 1,550 cm.$^{-1}$ in Proteins

The infra-red spectra of proteins and polypeptides show strong absorption bands around 1,650 cm.$^{-1}$ and 1,550 cm.$^{-1}$ related to the peptide group. The 1,650 cm.$^{-1}$ band has been associated with the C=O stretching motions and the 1,550 cm.$^{-1}$ band has been assumed by some investigators to be an N—H deformation frequency of the monosubstituted amide (peptide) group[1]. Examination of dried, deuterated films of proteins has shown that the 1,550 cm.$^{-1}$ band shifts to 1,450 cm.$^{-1}$, but there still remains considerable absorption in the 1,550 cm.$^{-1}$ region[2].

We have examined solutions of proteins in heavy water in a double-beam infra-red spectrometer, compensated by placing in the reference beam an equivalent thickness of solvent, and at their isoelectric points we have observed the presence of two bands at 1,575 cm.$^{-1}$ and 1,550 cm.$^{-1}$ as well as the previously known 1,450 cm.$^{-1}$ band associated with deuterated peptides (see Fig. 1). In general, the 1,575 cm.$^{-1}$ band cannot be seen in the infra-red spectra of non-deuterated proteins because of the overlapping strong absorption[3] at 1,550 cm.$^{-1}$. The absorption band at 1,575 cm.$^{-1}$ is present in alkaline heavy water solutions of proteins and disappears in acidic solutions, but upon bringing such solutions to *p*H 9–10 the band reappears. The same behaviour is observed in a weak band near 1,400 cm.$^{-1}$, previously shown to be associated with ionized carboxyl groups in amino-acids and peptides[4,5]. These experiments in heavy water solutions thus reveal the presence of a 1,575 cm.$^{-1}$ band in proteins which, like the 1,400 cm.$^{-1}$ band, may be correlated with $COO^{\ominus}$ groups.

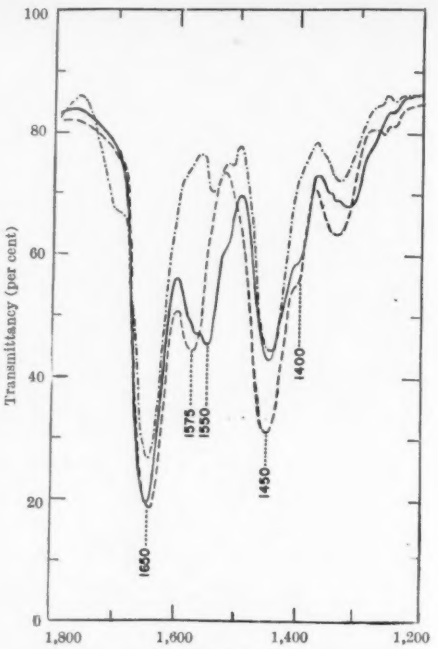

Fig. 1. Infra-red spectra of 10 per cent solutions of crystalline bovine plasma albumin in heavy water at various *p*H values: ———, at *p*H 6; – – – –, spectrum obtained upon bringing *p*H 6 solution to *p*H 9; – – –, spectrum obtained upon bringing *p*H 6 solution to *p*H 3

On the other hand, the band at 1,550 cm.$^{-1}$ remains upon acidification of heavy water solutions of proteins (which had been previously adjusted to the isoelectric point), but disappears in alkaline solutions. However, this change is irreversible; the 1,550 cm.$^{-1}$ band does not reappear upon acidification of alkaline heavy water solutions of proteins. Furthermore, if a heavy-water solution of plasma albumin, gamma globulin, or egg albumin at the isoelectric point is heated at 100° C. for two minutes, this 1,550 cm.$^{-1}$ band disappears. Judged by this behaviour, and since it lies at the same frequency as an original non-deuterated peptide absorption, this band may be associated with the peptide group as a whole, or a part of it which does not readily exchange its

hydrogen with heavy water in the native state at its isoelectric point or in acidic solutions, but which readily exchanges its hydrogen in alkaline media or during the changes of structure accompanying heat denaturation.

Thus from the infra-red spectra of proteins in heavy water solutions at various *p*H's, we can conclude that the protein absorption band noted in the region of 1,550 cm.$^{-1}$ is a complex absorption band associated in part with —COO$^{\ominus}$ groups (at 1,575 cm.$^{-1}$) and in part with two kinds of peptide linkages: one type of peptide grouping is easily deuterated at room temperature, the other type of peptide group being deuterated at elevated temperatures or in alkaline solutions.

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Microwave Spectrum of Penta-1 : 3-diyne

The preparation of penta-1 : 3-diyne was reported by Armitage, Jones and Whiting[1], and it has recently been emphasized[2] that chemical and ultra-violet spectroscopic evidence supports strongly the attributed structure. In confirmation, we have measured the microwave pure rotation spectrum of the substance made by this method, as observed in a video sweep spectrometer, and find it to be that of a symmetric-top molecule of structure $H_3C—C\equiv C—C\equiv C—H$, all five carbon atoms lying on the molecular axis.

Measurements have been made on the $J = 4 \rightarrow 5$, $5 \rightarrow 6$, $7 \rightarrow 8$ and $8 \rightarrow 9$ transitions, in all of which the expected K-splitting is well resolved. The spectroscopic constant B_0 is 2,035·73$_3$ Mc./s., and the distortion coefficient D_{JK} is 20·0 kc./s. The distortion coefficient D_J is very small, not more than 0·2 kc./s. Lines due to molecules in excited bending vibrational states are also observed and show the characteristic type of pattern predicted theoretically[3] and found for similar molecules[4,5]. Measurements on the fine structures are being extended, and will be given in a fuller report later.

The moment of inertia, I_B, derived from B_0, is $412{\cdot}09 \times 10^{-40}$ gm./cm.^{2}, in good agreement with the most probable interatomic distances. Thus the structure

$$H_3C\overset{1{\cdot}460}{—}C\equiv C\overset{1{\cdot}377}{—}C\equiv C\overset{1{\cdot}06}{—}H$$
$$\qquad\qquad\quad 1{\cdot}207 \qquad\quad 1{\cdot}207$$

(lengths in A.), with a tetrahedral methyl group in which d_{CH} is 1·10 A., is in accord with I_B. These bond-lengths are all close to values found for analogous bonds in related molecules, that for the central 'single' C—C bond being close to the 1·375 A. found for similar bonds in dimethyl triacetylene by Jeffrey and Rollett[6]. The spectrum is reasonably intense, showing that penta-1 : 3-diyne, like methyl acetylene, is unusual among hydrocarbons in having an appreciable electric dipole moment. We expect to detect spectra of $H_3CCCCCD$, and it seems reasonably probable that lines due to molecules containing carbon-13 will be detected in a Stark modulation spectrometer now available, and so permit evaluation of a considerable part of the molecular structure.

We are indebted to Prof. E. R. H. Jones and Dr. M. C. Whiting for the gift of a sample of 1 : 4-dichlorobut-2-yne, from which the penta-1 : 3-diyne was made. This work was carried out in collaboration with the Physics Department of the Telecommunications Research Establishment, Malvern, and made possible by the loan of microwave equipment from that Establishment.

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A New Isomer of Chlorogenic Acid from Peaches

Neochlorogenic acid, a new isomer of chlorogenic acid[1], has been isolated from Elberta and Halford peaches by the use of counter-current distribution. It differs from the isochlorogenic acid[2] isolated from coffee and it may be readily separated from chlorogenic acid which is present in somewhat larger amounts. Chlorogenic acid has been found in pears and apples[3] and its presence indicated in peaches[4].

An aqueous solution, freed of lipids, prepared from a water-saturated butanol extract of lyophilized peach *purée* was subjected to a 100-tube counter-current distribution[5] using the solvent pair ethyl acetate and 2*M* phosphate, *p*H 3·0. Analysis of the phenolic content of the tubes with Folin–Denis reagent[6] showed the presence of four bands. The first, $K \sim 0{\cdot}05$, consists of anthocyanins, polymeric and unknown materials. The second, $K = 0{\cdot}39$, is neochlorogenic acid. The third, $K = 1{\cdot}40$, is chlorogenic acid, which may be readily crystallized, and the fourth, $K > 10$, consists also of polymeric and unknown materials. (K, the distribution constant, is the ratio of concentration in the lighter phase to that in the heavier phase.) Isochlorogenic acid would be in the fourth band were it present.

The tubes containing the neochlorogenic acid were collected, ethanol was added (one-fifth the volume of the ethyl acetate layer) and the phases separated. Several further extractions of the aqueous layer with 80 per cent ethyl acetate – 20 per cent ethanol were made. These extracts were combined, concentrated, chilled and the precipitated sodium phosphate removed by filtration. The remaining sodium ions were removed by passing a 50 per cent alcohol solution through a column of 'Dowex-50'. Serious losses of neochlorogenic acid attended this operation. The eluate was concentrated *in vacuo*, whereupon crystallization occurred. Recrystallization could be effected from water or ethanol.

The ultra-violet absorption spectrum is typical of the other isomers[2]; the rotation is lower, $[\alpha]_D^7 - 5{\cdot}4°$ (50 per cent alcohol); m.p. 177–179° (dec.). The crystalline nature was further shown by its characteristic X-ray pattern. *Analysis:* calc. for $C_{16}H_{18}O_9$: C, 54·2; H, 5·12. Found: C, 54·2; H, 5·44. Neutral equivalent, using as indicator the yellow-green colour formed on neutralization by base, 367; calc., 354. A similar titration with chlorogenic acid hemihydrate gave a neutral equivalent of 366 (calc. 363).

Saponification of 12·8 mgm. of neochlorogenic acid with sodium hydroxide in a nitrogen atmosphere allowed the isolation of 6·5 mgm. (91 per cent) of caffeic acid hydrate, m.p. 178–180° (uncorr.). After recrystallization from water, it was shown by mixed melting point and X-ray pattern to be caffeic acid. Quinic acid was also isolated, in poorer yield, from the non-ether soluble fraction of the hydrolysis products. It, too, was identified by mixed melting point determination and comparison of its X-ray pattern with that of an authentic specimen.

The position of attachment of the caffeoyl group to the quinic acid is not known.

I wish to thank Mr. D. R. Black and Dr. K. J. Palmer for the X-ray data and Mr. L. R. White and Miss G. E. Secor for the ultimate analyses.

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A Fluorescence Test for Serotonin and Other Tryptamines

The current interest in naturally occurring tryptamines, and the recent report by Shepherd *et al.*[1] on the detection of serotonin (5-hydroxytryptamine), prompt us to describe a more sensitive and specific test which has been used for some time in our investigations on the pain-producing agent of burn-blister fluid[2].

This test, which appears to be specific for those tryptamines which do not carry substituents at position 2 or at either of the nitrogen atoms, nor with heavily substituted side-chains, is performed thus. The solution under investigation, suitably diluted, is either spotted on to filter paper or, better, subjected to paper chromatography in an appropriate solvent system. The paper is dried in air, treated with a solution of ninhydrin in acetone (0·2 per cent) containing 10 per cent v/v of glacial acetic acid (spray or dipping technique[3]), the acetone allowed to evaporate, and the paper heated in an oven at 90–100° for 2–3 min. After heating, the paper is examined in ultra-violet light (3650 A.); an area of intense blue-green fluorescence indicates a susceptible tryptamine.

The sensitivity of this test is such that 10^{-4} μmole/sq. cm. can readily be detected on a chromatogram; this corresponds to less than 0·02 μgm. of serotonin and is far beyond the sensitivity or specificity of the simple ninhydrin or Ehrlich colour reactions, or the fluorescence tests of Shepherd *et al.*[1] or of Udenfriend *et al.*[4]. Molar proportions of all the reacting tryptamines give very similar intensities and colours of fluorescence. The results shown in the table were obtained with tryptamine salts tested at a density on paper chromatograms of 10^{-3} μmole/sq. cm.

Tryptamine substituents	Appearance after treatment	
	Colour in visible light	Fluorescence in ultra-violet light
None (tryptamin)	—	bright blue-green
5-Hydroxy (serotonin)	—	bright blue-green
1-Methyl	strong pink, slowly fading	pale green after visible colour fades
2-Methyl	—	none
α-Methyl	—	bright blue-green
α-Ethyl	—	bright blue-green
α : α-Dimethyl	—	very faint golden
N : N-Dimethyl	—	none
α-Carboxy (tryptophan)	—	none

No fluorescence is given by tryptophan at any concentration. Furthermore, the purple ninhydrin colour from tryptophan or other amino-acid will not obscure the characteristic fluorescence of much smaller amounts of tryptamines mixed with the amino-acid. More than a hundred other amines, amino-acids and indoles have been tested, but none gives the characteristic fluorescence. The test works equally well on all types of filter-paper, including a specially purified paper, 10/*S*, supplied by Messrs. J. B. Green, Ltd., and with chromatograms run in acidic, basic or phenolic solvents (though the latter tend to destroy serotonin). The intensity of fluorescence is much reduced unless acetic acid is present in the ninhydrin reagent; this may explain why the great sensitivity and selectivity of this reaction was not noticed by Harris and Pollock, who first mentioned it[5].

The high-intensity fluorescence of the products of the reaction suggests that they are β-carboline derivatives. This view is supported by the negative results with certain substituted tryptamines. Substitution of the side-chain NH_2— would prevent condensation with a carbonyl compound; substitution at position 2 would prevent ring-closure of the condensed side-chain; di-substitution (but not mono-substitution) at the α-carbon atom would prevent dehydrogenation to the carboline; and many carbolines substituted at the indole-nitrogen have diminished fluorescence. Further investigations on the mechanism and specificity are in progress, but in the meantime the test should prove useful for studying the tryptamines in natural materials[3,4,6].

We are grateful to Prof. E. C. Dodds and Prof. C. A. Keele for their encouragement.

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Effect of Tri-*ortho*-cresyl Phosphate on the Absorption of Tocopherol

In 1943, Bloch and Hottinger[1] found that the toxicity of tri-*ortho*-cresyl phosphate to rabbits was considerably diminished when the rabbits were fed tocopherol acetate simultaneously with the tri-*ortho*-cresyl phosphate. Meunier *et al.*[2] administered tocopherol acetate daily to rabbits and determined the concentration of tocopherol in the plasma before and after feeding a lethal dose of tri-*ortho*-cresyl phosphate; it was found that tri-*ortho*-cresyl phosphate caused a pronounced fall in plasma tocopherol. These experiments have led to the supposition that tri-*ortho*-cresyl phosphate has an anti-vitamin E action.

The results obtained by Thompson *et al.*[3–5] have directed recent interest towards the demyelination and paralysis seen in chickens 10–14 days after feeding 1 ml. tri-*ortho*-cresyl phosphate/kgm. These workers pointed out that tri-*ortho*-cresyl phosphate appears to exert a highly selective inhibitory action on the pseudo-cholinesterase which is found in myelin sheaths; however, other investigators have shown that inhibition of the pseudo-cholinesterase in other species[6] or by other compounds[7] does not always result in either demyelination or paralysis. In view of the decrease in tri-*ortho*-cresyl phosphate toxicity effected by tocopherol acetate[1,3], it seemed of interest to investigate the possible antagonism between tocopherol and tri-*ortho*-cresyl phosphate in chickens.

Chickens were fed 50 mgm. D,L-α-tocopherol in 0·3 ml. arachis oil solution daily and the concentration of tocopherol in the plasma was determined daily by a modification of known methods[8,9]. The tocopherol concentration rose from about 0·2 mgm. per cent to 4 mgm. per cent after the first dose of tocopherol and to 5·5 mgm. per cent after the second dose. If the chickens were fed once with 1 ml. tri-*ortho*-cresyl phosphate/kgm. on the first day, the concentration of tocopherol in plasma failed to rise above 0·3 mgm. per cent after feeding the tocopherol. Similar results were obtained with tri-*ortho*-cresyl phosphate and tocopherol acetate.

If the concentration of tocopherol in the plasma was first raised to a high level by repeated doses of tocopherol acetate before the tri-*ortho*-cresyl phosphate was administered, it was found that the plasma concentration decreased by 60 per cent in two days after feeding the tri-*ortho*-cresyl phosphate, despite the continued administration of tocopherol acetate. The tocopherol concentration in the plasma of the control group also decreased by 60 per cent in two days when the administration of tocopherol acetate was discontinued. The apparent anti-vitamin E action of tri-*ortho*-cresyl phosphate in these experiments and in those of Meunier *et al.*[2] would thus appear to be due to the fact that tri-*ortho*-cresyl phosphate prevents the absorption of tocopherol and tocopherol acetate from the intestine.

The administration of free tocopherol does not prevent either the pseudo-cholinesterase inhibition or the paralysis caused by the administration of tri-*ortho*-cresyl phosphate. Thus when tocopherol and tri-*ortho*-cresyl phosphate are given to chickens, the latter is absorbed from the intestine but the former is not. However, when tocopherol acetate and tri-*ortho*-cresyl phosphate are given simultaneously, the pseudo-cholinesterase is only partially inhibited and the chickens do not become paralysed even after a second dose of tri-*ortho*-cresyl phosphate. Since tocopherol acetate is recovered from the plasma in the form of free tocopherol, it is apparent that neither the tri-*ortho*-cresyl phosphate nor the tocopherol acetate is well absorbed from the intestine in the above experiments. It seems highly probable that the results obtained by Bloch and Hottinger[1] must be explained on this basis.

Although tri-*ortho*-cresyl phosphate can be regarded as an 'antagonist' of vitamin E in the normal animal because it prevents this vitamin from being absorbed, the toxicity of tri-*ortho*-cresyl phosphate to chickens cannot be diminished by previous administration of free tocopherol which raises the plasma concentration to a high level[10]. The mechanism by which tri-*ortho*-cresyl phosphate prevents the absorption of tocopherol is not yet clear. However, it seems possible that tri-*ortho*-cresyl phosphate might also interfere with the utilization of other fat-soluble alcohols.

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Structure of Insulin

In a recent communication[1], I described all the structures of insulin, based on the α-helix of Pauling, Corey and Branson, which the use of atomic models had shown to be sterically possible. Arndt and Riley[2] have criticized my conclusion that an intra-chain cystine link cannot be formed between the seventh and eleventh residues of the *A*-chains. In order to form this link, Arndt and Riley have distorted the helix until it has almost a four-fold screw axis (helix angle 92°, helix translation 1·4 A.) while reducing the hydrogen-bond distance to 2·6 A.

It is doubtful whether this can be correctly or usefully called the α-helix of Pauling, Corey and Branson, and in any event it would be a structure of higher internal energy and its existence would only be favoured if the formation of the intra-chain link contributed to its stability. This, however, does not seem to be the case. In their C—S—S—C link, as compared to the values obtained from dimethyl disulphide[3], two C—C—S angles have been increased by 5°, and two C—S—S angles by 11°, while the S—S, C_β—S and C_α—C_β bond-lengths have been increased by 0·21, 0·12 and 0·03 A. respectively. The energy involved in such a degree of strain would be of the order of several kilocalories, and the tendency would be for the relevant part of the chain to unwind and form a more stable intra- or inter-hydrogen-bonded configuration. The models show

that such an unwinding of the helix would be sterically possible.

Arndt and Riley are correct in saying that the α-helix should not be treated as a "perfect immutable structure"; but the point at issue is what degree of strain or distortion may be considered reasonable. The structures I put forward involved very little strain, and on the other hand no structure was rejected unless it was impossible to build it even by distorting the helices to the considerable extent which will be defined in the fuller account to be published elsewhere.

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Restricted Rotation in Polar Gases near the Critical Point

David, Hamann and Pearse[1], in a recent communication in *Nature*, attributed the onset in dielectric loss to a fairly sharp transition to restricted rotation in gaseous methyl fluoride at densities somewhat above the critical value. In a subsequent publication[2], they claimed added support for this hypothesis by showing that the correlation parameter g of Kirkwood's theory[3] of dielectric polarization increases markedly above unity, the value which it would attain in the absence of such restricted rotation. It is the purpose of this communication to point out that the behaviour of g found by David, Hamann and Pearse is the result of an inappropriate method of calculation, and that the dielectric loss observed can be interpreted without any assumption of a sharp transition to a state characterized by restricted rotation.

The values of g were calculated by David, Hamann and Pearse upon the assumption that the dipole moment of the molecules is the vacuum dipole moment. This assumption is not justified, since application of the Onsager reaction field theory[4] shows that the effective moment of a molecule increases as the pressure is increased, due to the additional moment induced by the neighbouring molecules. Another correction which must be taken into account is the refinement of Kirkwood's theory to include the effect of distortion polarization[5]. Values of g obtained by means of the modified equation and the effective dipole moment do not show the qualitative trend reported by David, Hamann and Pearse, and in fact indicate that any restriction of rotation must be extremely small. Values of g calculated, first, by David, Hamann and Pearse; secondly, by the use of Kirkwood's equation and the appropriate dipole moment; and finally, by the modified equation, are shown in the accompanying table. The scattering of values of g about unity observed in column 3 of the table indicates that so far as this calculation is concerned no definite evidence exists for restricted rotation. The values of g below unity at the higher pressures may be ascribed to the larger experimental errors incurred under these conditions. However, it should be pointed out that contra-association ($g < 1$) is observed in several liquid

Correlation Parameter of Methyl Fluoride at 50° C.

Density (moles/l.)	g (D., H. and P.)	g (Kirkwood eq.)	g (H. and A. eq.)
0·960	1·00	1·00	1·00
2·265	1·02	1·00	0·99
3·997	1·04	1·02	1·00
6·60	1·08	1·04	1·00
7·70	1·15	1·05	1·00
8·83 = d_c			
9·24	1·18	1·05	1·00
10·28	1·19	1·07	0·99
11·78	1·23	1·08	0·98
12·97	1·30	1·09	0·99
14·02	1·33	1·10	0·98

alkyl halides[5], and that a decrease in g at high densities is not unexpected.

The process described by David, Hamann and Pearse of lining up the molecules like cigars in the gas phase, that is, a sudden transition to a rotationally ordered state, cannot occur in a gaseous system, as has been shown in a general way by statistical mechanical methods[6]. However, a gradual increase in directionally dependent interaction is, of course, possible as the density is increased, and is in fact indicated by the dielectric loss measurements. Although such interaction should increase rapidly near condensation regions, and therefore near the critical point, the increase is not peculiar to the critical density, and should occur at increasingly greater densities as the temperature is increased above the critical value.

We therefore suggest that the phenomenon observed by David, Hamann and Pearse is due to the increased coupling of molecules as the distances between them is decreased.

For molecules where the angularly dependent component of the intereaction potential is much stronger as, for example, in HF, the lining up of molecules in the gas phase is more pronounced, but even then no sharp 'rotational phase change' is possible.

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March 25.

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[1] David, H. G., Hamann, S. D., and Pearse, J. F., *Nature*, **169**, 1106 (1952).
[2] David, H. G., Hamann, S. D., and Pearse, J. F., *J. Chem. Phys.*, **20**, 969 (1952).
[3] Kirkwood, J. G., *J. Chem. Phys.*, **7**, 911 (1939).
[4] Onsager, L., *J. Amer. Chem. Soc.*, **53**, 1486 (1936).
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Measurements of the Terrestrial Magnetic Field in the *E*-Layer

In a previous communication[1], we remarked briefly that gyrointeraction of radio-waves gives the measure of the total intensity H of the earth's magnetic field in the lower part of the E-layer, which extends approximately 90–95 km. above ground-level. This measurement reveals the presence of the electric currents in the E-layer which are postulated to account for terrestrial magnetic variations. The method is the only one by which H can be measured continually in the E-layer. It is only necessary to find

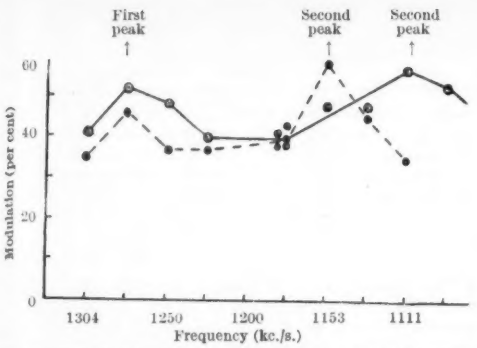

Fig. 1. Results of experiments made on June 7, 1950 (full curve), and on June 30, 1951 (broken curve)

resonance curves with two maxima lying equidistant from the local gyrofrequency[1]. The mean value of two frequencies at the position of the maxima is the gyrofrequency Ω. Because $\Omega = eH/2\pi mc$ [1], where e is the electronic charge, m is the electronic mass and c is the velocity of light, it is possible to calculate H. Table 1 shows values of H found in Italy by gyro-interaction.

An easier method, which is at the same time sufficiently precise, is self-demodulation of radio-waves, a phenomenon recently observed by me[2]. This phenomenon is substantially different from gyro-interaction.

If the radio-wave from a transmitter is modulated, for example, at 230 c./s., with the percentage modulation kept strictly constant at 80 per cent, and its carrier frequency varied around the local gyro-frequency (in the case of Fig. 1 from 1,276·1 to 1,090·9 kc./s.), we find that at a receiving station at least 200 km. distant from the transmitting station the percentage modulation of the signal varies as shown in Fig. 1. The minimum of the percentage of modulation received (the maximum of demodulation) is at the gyrofrequency. The mean value of the frequencies at which maxima of Fig. 1 lie gives the gyrofrequency and, from the formula $\Omega = eH/2\pi mc$, H in the E-layer can be calculated. To measure the gyrofrequency, it is sufficient for a station to radiate power of only 3–5 kW., but it should be able to vary its carrier-frequency continuously about the local gyrofrequency. The receiving station consists of a selective receiver tuned to the transmitter, with its intermediate-frequency output coupled to an oscillo-graph. The envelope of the oscillograph trace gives a measure of the percentage of modulation. It is desirable to take a number of measurements at each carrier-frequency emitted. In Fig. 1 every point is the mean value of many measurements.

Table 1

Date	Method	Locality of emitting station	Locality of receiving station	Sky-point to which H value is referred	H (oersted)
3.7.1949	Gyrointer-action	Florence	Turin	Monte-falco (Foligno)	0·434
6.7.1949	Gyrointer-action	Florence	Turin	Monte-falco	0·431
13.7.1949	Gyrointer-action	Florence	Turin	Monte-falco	0·423
7.6.1950	Self-de-modulation	Florence	Turin	44° 25′ N. 9° 27′ E.	0·424
23.7.1950	Self-de-modulation	Florence	Naples	42° 18′ N. 12° 54′ E.	0·430
29.7.1950	Self-de-modulation	Florence	Naples	42° 18′ N. 12° 54′ E.	0·443*
30.6.1951	Self-de-modulation	Florence	Turin	44° 25′ N. 9° 27′ E.	0·432

* Probably because the frequency of the first maximum does not recur.

Table 1 contains some values of H found in Italy by self-demodulation. The degree of precision may reach the third decimal figure. The small changes of the frequencies on which the maxima lie show the variations of the magnetic field in the ionosphere. As H at ground-level during the experiments was 0·4477 oersted, we see that H in the E-layer is smaller than on the earth.

Further details of the method will be given in *Il Nuovo Cimento*.

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May 16.

[1] Cutolo, M., *Nature*, **166**, 98 (1950); *Il Nuovo Cimento*, **9**, No. 5 (1952).

[2] Cutolo, M., *Nature*, **167**, 314 (1951); *Il Nuovo Cimento*, **9**, No. 8 (1952).

A Method of Changing the Isotope Abundance in Mercury

In order to investigate the possibility of changing the isotope composition of mercury merely by passing a direct electric current through it under certain conditions, the following experiments were carried out.

Mercury of analytical grade was distilled under vacuum in a 'Pyrex' glass apparatus and was then sucked up into a glass cell fitted with tungsten electrodes (see Fig. 1). The diaphragm tube was 140 mm. long and 2 mm. inside diameter, and was filled with glass beads (0·09–0·15 mm. diameter) between two sintered glass plates, forming the top and the bottom of the diaphragm. 1·430 gm. of mercury above the diaphragm made contact with the top electrode. A direct current was passed through the cell with the negative electrode at the bottom.

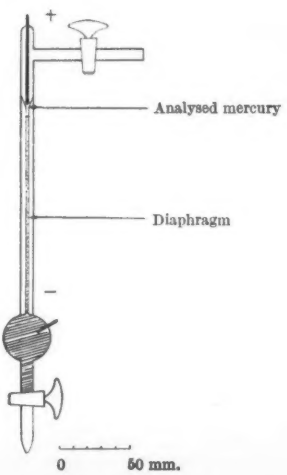

Fig. 1. Mercury cell

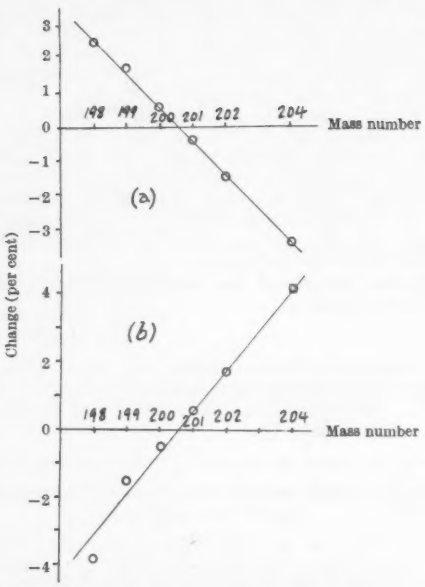

Fig. 2. Change in relative isotope abundance in the mercury above the diaphragm of apparatus shown in Fig. 1. (*a*) Top electrode positive. (*b*) Top electrode negative

The whole cell was immersed in a constant-temperature bath at 15° C. The experiment lasted about 2,000 hr. The mean voltage was 3·40 V. and the mean current 22·6 amp. Immediately after the current was shut off, the mercury above the diaphragm was removed. This mercury has been analysed by the mass spectrometer group at this laboratory and was then compared with a control sample of the mercury used. The result is given in Table 1 and Fig. 2 (*a*).

Another experiment was carried out in the same way except that the current direction this time was changed and the top electrode was made negative. In this case also the mercury above the diaphragm was taken for analysis. The result is given in Table 2 and Fig. 2 (*b*).

The results of these two experiments indicate the rather surprising effect that the light isotopes of mercury are enriched at the anode end of the cell and the heavy isotopes at the cathode.

Similar experiments have been made with amalgams and with a solid metal wire; but as yet it has not been possible to study the isotopic compositions of these samples.

Table 1. (Top electrode positive)

Mass number	Relative abundance (per cent)		Change in relative abundance* (per cent)
	Control sample	Cell sample	
198	10·10	10·35	+ 2·5 ± 0·3
199	17·05	17·35	+ 1·76 ± 0·2
200	23·25	23·40	+ 0·6 ± 0·2
201	13·27	13·22	− 0·4 ± 0·2
202	29·60	29·15	− 1·54 ± 0·2
204	6·67	6·44	− 3·45 ± 0·2
	99·94	99·91	

* The error given with each value of the change in relative abundance is the maximum deviation in a series of six measurements.

Table 2. (Top electrode negative)

Mass number	Relative abundance (per cent)		Change in relative abundance (per cent)
	Control sample	Cell sample	
198	10·06	9·68	− 3·8 ± 0·4
199	17·03	16·78	− 1·5 ± 0·3
200	23·32	23·20	− 0·5 ± 0·3
201	13·27	13·35	+ 0·6 ± 0·3
202	29·60	30·10	+ 1·7 ± 0·2
204	6·66	6·94	+ 4·2 ± 0·4
	99·94	100·05	

The same sort of diaphragm as that used here has been used by A. Klemm *et al.*[1] in experiments on the electrolysis of fused salts. K. Schwartz[2] has made density measurements after passing $9·6 \times 10^6$ coulombs through 100 gm. of mercury in a cell in which the anode and cathode compartments were connected by a capillary, but no change in abundance of the isotopes was detected.

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Aug. 8.

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Interaction between Surfaces in Close Proximity

According to theories of the interaction of double layers[1,2], two surfaces in close proximity are mutually repelled by a force which increases as the surfaces are brought together. Therefore, if an air bubble is pressed against a plane glass surface under water, the disjoining film of water should reach an equilibrium thickness at which the double layer repulsion is balanced by the excess pressure of the bubble.

By an interferometric method, Derjaguin and Kusakov[3] showed that this equilibrium thickness was about 1000 A., and, as was expected, varied with the excess pressure. Later, Elton[4] showed conclusively that, given sufficient time, the disjoining film between a bubble and a silica surface thinned to well below 200 A., and claimed, therefore, that the films observed by Derjaguin and Kusakov were not at equilibrium, but were thinning at a slow but measurable rate. The latter authors have since reaffirmed their earlier conclusions[5].

The results of similar experiments in this laboratory may resolve this controversy. When extreme care is taken to exclude surface-active impurities, Elton's results are duplicated for both silica and glass surfaces. However, in a solution containing 3×10^{-4} molar sodium hexadecyl sulphate an equilibrium film approximately 1000 A. thick is obtained, which responds to changes in bubble pressure, temperature variation and electrolyte concentration, in precisely the same way as did the films which Derjaguin and Kusakov obtained in what they described as 'pure' water. It has been found extremely difficult to prevent the same effect arising from contamination of the bubble surface, and the results of Derjaguin and Kusakov are almost certainly due to such accidental contamination. The existence of an

equilibrium film of measurable thickness in solutions of sodium hexadecyl sulphate thus presents the possibility of measuring the repulsion between double layers under known conditions.

A special precaution must be taken when making these measurements in dilute solutions of surface-active substances, because of the slow attainment of surface tension equilibrium. As adsorption proceeds, the limited volume of solution in the disjoining film is more rapidly depleted of adsorbent than the free solution, so that, after a time, adsorption proceeds at a lower rate on the flattened portion of the bubble surface than elsewhere. Under the surface tension gradient set up, surface diffusion takes place, with the result that liquid is continually carried into the disjoining film by surface transport[6]. If this rate of inflow should equal the rate of outflow due to the excess bubble pressure, one may wrongly gain the impression of an equilibrium film of excessive thickness. Thus one must ensure that adsorption is complete before making the measurements.

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Industrial Research Organization,
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June 12.

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Pancreatic Lipase: a Scheme of its Specificity and a Hypothesis of the Mechanism of its Action

The specificity of pancreatic lipase has not hitherto been readily defined. Lipase can hydrolyse many esters, but acts best on those derived from long-chain fatty acids[1]. Less attention has been paid to the effect on esterolysis of that part of the ester derived from the alcohol; glyceryl and benzyl groups have been found to influence the reaction most favourably, while aliphatic groups exercise a restraint which increases with the length of their carbon chain[2].

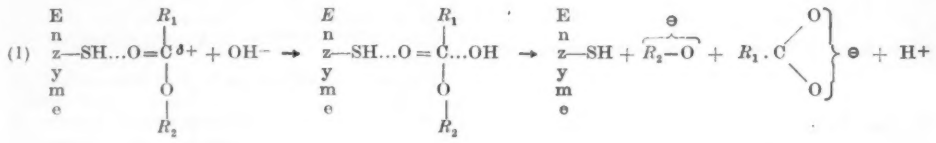
From the available evidence[1], the following conditions appear to be necessary for lipase to exert its optimal action: (1) the acid residue should be electron donating; (2) the alcohol residue should be electron attracting.

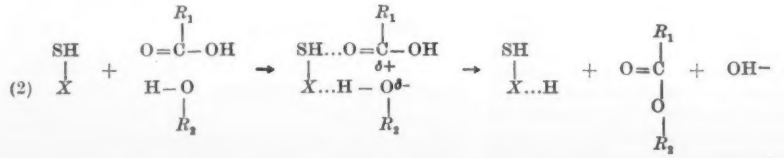
The action of lipase is inhibited by aldehydes and ketones with an intensity which increases with the size of the alphyl group attached to the carbonyl group. The inhibition is especially strong when the carbonyl group is adjacent to a phenyl nucleus, as in benzaldehyde or acetophenone[3,4]. Thus high affinity for the enzyme in esters, aldehydes and ketones is associated with a structure which produces a high electron density at the 'carbonyl' oxygen, either by an inductive or a mesomeric effect. On this basis, pancreatic lipase may be defined as a hydrolase specific for organic esters, which have an affinity for the enzyme proportional to the size of the negative charge at the 'carbonyl' oxygen.

It is suggested that the nucleophilic oxygen reacts with an electrophilic centre on the enzyme, and that this centre is the —SH group which is essential for the action of lipase. Between the two groups a hydrogen bond can form. In consequence, electron density at the 'carbonyl' carbon decreases and approach of hydroxyl ions is facilitated (1). The ease of hydrolysis of the substrates of lipase in non-enzymic alkaline conditions varies inversely with their ability to undergo cleavage by lipase, but varies directly with the tendency to form this hydrogen bond, in the lower members of the series. Synthesis may be facilitated in a similar way 2); that is, hydrogen bonding occurs between the alcoholic hydrogen and a strongly electronegative centre, X, on the enzyme, as well as between the 'carbonyl' oxygen and the —SH group. The two hydrogen bonds increase the difference in charge between the 'carbonyl' carbon and the alcoholic oxygen, and therefore reduce the activation energy for the esterification reaction.

The balance between synthesis and hydrolysis depends on the hydroxyl ion concentration. On this basis synthesis in alkaline media containing only the carboxyl anion would be unlikely. So far as is known, no synthesis has been reported in any but an acid medium[5].

It is implied that there is only one link between substrate and enzyme during hydrolysis, and two during synthesis. The strongly favourable influence exerted by some alcohol residues on hydrolysis is therefore attributed to their ability to stabilize the ion $\overbrace{R\text{—O}}^{\ominus}$, and their capacity for withdrawing electrons, which directly assist the function of the hydrogen bond. In other words, the dominating factor in the combination of ester with lipase is the structure

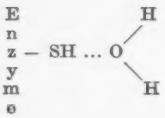




of the acid, while the alcohol moiety plays a part in the ease of breakdown of the complex.

The benzoates have considerable affinity for lipase, probably because of the conjugation of the 'carbonyl' group with the phenyl nucleus, but this conjugation must be lost on hydrolysis. The enzyme is apparently incapable of facilitating this process, with the result that the benzoates are not more easily hydrolysed when in combination with the enzyme than they are in the free state[3]. It seems that the enzyme is best suited to overcome unfavourable influences on hydrolysis due to inductive effects.

If this hypothesis is correct, other hydrogen-bonding substances will combine with the enzyme. This may be the mechanism of the inhibition exerted by fluoride ions[4]. Similarly, combination with water is possible.



This reaction may explain the apparently slight affinity for lipase shown by substrates (for example, triacetin, tripropionin and 'Tween 20'[7]) in homogeneous solution, although when an oil–water interface is present the affinity is very much greater[8]. The surface-active properties of lipase tend to bring it to such an interface[5], where the concentration of water is small compared with the concentration of substrate. The linear relationship between the concentration of triacetin and the rate of hydrolysis[9] may perhaps be due to competitive inhibition by water.

This hypothesis attributes to the enzyme the function of inducing, by means of hydrogen bonding, electronic shifts at appropriate points in the substrate, thereby speeding up the reactions which these compounds normally but with difficulty undergo. Surface-action effects, which are very important in catalysis by lipase, probably enhance the efficiency and specificity of this process.

J. E. Scott

Royal Infirmary,
Manchester.
April 16.

[1] Sumner, J. B., and Myrbäck, K., "The Enzymes", 1, Pt. 1, 390 *et seq.* (Academic Press, New York, 1951).
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[4] Weinstein, S. S., and Wynne, A. M., *J. Biol. Chem.*, **112**, 649 (1935).
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[8] Schonheyder, F., and Volquartz, K., *Acta Physiol. Scand.*, **9**, 57 (1945).
[9] Schonheyder, F., and Volquartz, K., *Acta Physiol. Scand.*, **7**, 376 (1944).

Errors in the Estimation of Serial Correlations

Since the introduction of the serial correlation coefficient by Yule[1] the method of correlogram analysis has been extensively used. As a rule, the correlogram analysis has been preceded by a smoothing process for the removal of trend (either by curve fitting or moving averages), and the serial correlations are estimated from the residuals. Although it is quite generally realized that parameters so estimated are liable to bias, the form and full extent of this bias have not been extensively investigated.

These biases may have serious effects on the practical analysis of time series. The removal of any fitted constants will affect the correlogram, and tests of goodness of fit will be vitiated. In particular, the moving average method of trend elimination may give rise to a correlogram entirely different from that of the parent process.

The bias arises from two sources. In the first place, the serial correlation coefficient is the ratio of the serial covariance to the variance of the series. When these quantities are estimated from the data they are themselves subject to sampling error, and so the expectation of their ratio is not in general equal to the parent serial correlation. This bias always reduces the absolute value of the serial correlation, and disappears only when the parent serial correlation is zero. Secondly, the fitting of constants to the series introduces further bias. For example, when the mean is estimated from the data, a negative bias is introduced into the estimated serial covariance, reducing the value of the serial correlation.

When the mean only is fitted from the data, the serial correlation may be estimated as :

$$r_k = \frac{\frac{1}{n-k}\left\{\sum_{i=1}^{n-k} x_i x_{i+k} - \frac{1}{n-k}\left(\sum_{i=1}^{n-k} x_i\right)\left(\sum_{i=1}^{n-k} x_{i+k}\right)\right\}}{\frac{1}{n}\left\{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right\}}$$

Using this definition, the biases in the serial correlations may be found in special cases. For example, for the moving average $x_t = \varepsilon_{t-1} + \varepsilon_t$,

$$E(r_1) = \frac{1}{2} - \frac{3}{2n} + 0\left(\frac{1}{n^2}\right),$$

so that the bias, to order $1/n$, is $-3/2n$. For the Markoff process $x_t = \rho x_{t-1} + \varepsilon_t$,

$$E(r_1) = \rho - \frac{1+3\rho}{n} + 0\left(\frac{1}{n^2}\right).$$

These biases are larger than has generally been supposed. For example, for a Markoff process with parameter 0·8, the expectation of r_1 in a series of twenty terms when the mean is estimated is 0·630. The only previous work on this subject is by Sastry[2]. He calculated the bias due to fitting the mean, but neglected the first source of bias mentioned above, and in consequence the biases he gives are much too small. For example, using a slightly different definition of r_1, he gives the expectation of r_1 in series of twenty terms from a Markoff process with parameter 0·8 as 0·690, under-estimating the bias by 35 per cent.

Extensive calculations have been carried out on artificially constructed stochastic series confirming these results. Work is at present in process on the effect of various methods of trend removal, and detailed accounts will be published elsewhere.

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F. H. C. Marriott

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July 3.

[1] Yule, G. U., *J. Roy. Stat. Soc.*, **84**, 497 (1921).
[2] Sastry, A. S. R., *Sankhya*, **11**, 281 (1951).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 26

NUTRITION SOCIETY (joint meeting with the ROYAL GEOGRAPHICAL SOCIETY, at the Royal Geographical Society, Kensington Gore, London, S.W.7), at 2.30 p.m.—Symposium on "The Provisioning of Expeditions in the Field".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Prof. E. N. da C. Andrade, F.R.S.: "The Work of Robert Hooke".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Long-Playing Disk Records Compared with Magnetic Tape for Sound Reproduction in the Home".

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE (at Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. Paul Russell: "The Unfolding of Malaria Etiology" ("Man's Mastery of Malaria", 1) (Heath Clark Lecture).* (Further Lectures on October 27, 28, 29 and 30.)

Tuesday, October 27

CO-ORDINATING ADVISORY COMMITTEE ON OIL POLLUTION OF THE SEA, I.C.B.P., BRITISH SECTION (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 11 a.m.—Conference on "Oil Pollution of the Sea" (admission by ticket, obtainable from Miss P. Barclay-Smith, Secretary of the above Committee, c/o British Museum (Natural History), Cromwell Road, London, S.W.7).

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. R. H. Garstang: "Life on Other Worlds".*

COMMUNICATIONS RESEARCH CENTRE (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. J. Ayer: "What is Communication?"*

ROYAL SOCIETY OF MEDICINE, EXPERIMENTAL MEDICINE AND THERAPEUTICS SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "Survival of Tissue at Low Temperatures".

BIRKBECK COLLEGE (at Malet Street, London, W.C.1), at 6 p.m.—Prof. W. S. Bullough: "The History of Hormones".*

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. A. R. Aikman, Mr. J. McMillan and Mr. A. W. Morrison: "Static and Dynamic Performance of Sheathed Industrial Thermometers".

Wednesday, October 28

POSTGRADUATE MEDICAL SCHOOL OF LONDON (at Ducane Road, Shepherd's Bush, London, W.12), at 2 p.m.—Prof. G. F. Marrian, F.R.S.: "Steroid Metabolism".* (Further Lectures on October 29 and 30.)

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. G. Brazier: Chairman's Address.

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. A. E. Bender: "Nutritional Reappraisal—Proteins".

Wednesday, October 28—Friday, October 30

INSTITUTE OF PETROLEUM, HYDROCARBON RESEARCH GROUP (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2) —Conference on "Applied Mass Spectrometry".

Thursday, October 29—Friday, October 30

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX (at Bradford)—Northern Branch Conference.

Friday, October 30

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. D. F. Galloway: "Some Practical Aspects of Cutting Tool Nomenclature Arising from Recent Research".

NORTH EAST COAST INSTITUTE OF ENGINEERS AND SHIPBUILDERS (at the Literary and Philosophical Society, Newcastle-upon-Tyne), at 6.15 p.m.—Dr. C. Sykes, F.R.S.: "Internal Stresses in Some Types of Forgings" (Andrew Laing Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—The Right Hon. Lord Samuel: "Philosophy and Present-Day Physics".

Saturday, October 31

ASSOCIATION OF CLINICAL BIOCHEMISTS, N.W. REGION (in the Department of Physiotherapy, Crumpsall Hospital, Manchester 8), at 2 p.m.—6th Scientific Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with honours degree in civil engineering or equivalent qualifications, and professional or industrial and teaching experience) IN CIVIL ENGINEERING—The Director, Robert Gordon's Technical College, Aberdeen (October 28).

ASSISTANT (Grade B) (interested in research) IN THE DEPARTMENT OF MATHEMATICS, Technical College, Bradford, to undertake work at degree level—The Director of Education, Town Hall, Bradford (October 29).

SUPERINTENDENT (Superintending Scientist) (with university degree of high standard in physical science or engineering, and extensive experience in research and development work, including the directing of such work) AT THE LONG RANGE WEAPONS ESTABLISHMENT, Missile Flight Research Division, Salisbury, South Australia, to direct research and development work concerned mainly with the behaviour of guided missiles in flight—The Senior Representative, Departments of Defence, Production and Supply, Australia House, Strand, London, W.C.2 (October 29).

GRADUATE IN PHYSICS (with good theoretical knowledge of refrigeration, and preferably with practical experience of absorption systems) at the North Thames Gas Board Laboratories, Watson House, Fulham, London, S.W.6, to carry out research and development on absorption refrigerators—The Staff Controller, North Thames Gas Board, 30 Kensington Church Street, London, W.8, quoting 666/109 (October 30).

RESEARCH FELLOW IN PURE MATHEMATICS—The Registrar, The University, Edgbaston, Birmingham 15 (October 30).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, University College, Leicester (October 31).

BIOCHEMIST (honours science graduate) primarily for research duties in the Geriatric Department of the Sunderland Hospital Group—Senior Administrative Medical Officer, Newcastle Regional Hospital Board, "Blythswood South", Osborne Road, Newcastle upon Tyne 3 (October 31).

LECTURER (preferably with special interest in some branch of applied mathematics) IN MATHEMATICS—The Registrar, College of Technology, Manchester 1 (November 2).

CHIEF ENGINEER to the London Electricity Board—The Chairman, London Electricity Board, 46 New Broad Street, London, E.C.2 (November 6).

ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, Trinity College, Dublin (November 7).

RESEARCH ASSISTANT (with good honours degree in zoology, special interest in the problems of animal behaviour, and some knowledge of physiology, experimental psychology or physics) at the Dove Marine Laboratory, to assist in researches into the behaviour of fishes of commercial importance and in the compilation of existing data on this subject—The Registrar, King's College, Newcastle-upon-Tyne (November 7).

LECTURER (preferably with special interest in electronic and/or communication engineering) IN ELECTRICAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (November 9).

ASSISTANT (graduate in chemistry, and postgraduate experience in biochemistry) IN BIOCHEMISTRY, for research at the Institute of Orthopædics Biochemical Laboratories, Stanmore—The Dean, Institute of Orthopædics, 234 Great Portland Street, London, W.1 (November 10).

ASSISTANT IN NATURAL HISTORY—The Secretary, The University, Aberdeen (November 15).

ASSISTANT DIRECTOR (graduate in engineering, physics, chemistry or microbiology, and experience of research in the preservation, processing and transport of food, preferably fish) AT THE FISHING INDUSTRY RESEARCH INSTITUTE, Cape Town, South Africa—The Secretary, P.O. Box 1233, Cape Town, South Africa (November 16).

RESEARCH ASSISTANT IN MINING (graduate in science or engineering, and preferably with some qualifications or experience in hydraulics) —The Registrar, The University, Leeds 2 (November 16).

UNITED STEEL COMPANIES RESEARCH FELLOWSHIP IN METALLURGY —The Registrar, The University Sheffield (November 18).

LECTURER IN PHYSIOLOGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (New Zealand, November 30).

LECTURER IN GEOGRAPHY—The Registrar, University College, Aberdeen (December 30).

CHAIR OF PHYSICS—The Registrar, University College, Hull (January 16).

AGRONOMIST (with good honours degree, preferably in botany or natural science, and at least two years appropriate postgraduate experience) at the West African Institute for Oil Palm Research, Nigeria, for work in connexion with improvement of the cultivation of the oil palm, including fertilizer and cultural trials—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.87/11/08.

ASSISTANT ENTOMOLOGIST (preferably with honours degree in zoology, specializing in entomology, and experience in rearing of live insects, and knowledge of standard laboratory techniques) IN THE RESEARCH BRANCH OF THE FORESTRY COMMISSION, Alice Holt, Surrey, to take general charge of laboratory investigation and raising stocks of parasites, predators, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.321/53A.

CHEMISTS (with at least H.S.C. (science) or equivalent, but further training in chemistry to H.N.C., A.R.I.C. or degree may be an advantage) in the Ministry of Supply Atomic Weapons Research Establishment, Aldermaston, Berks, for work on analysis, gases, organic compounds (microcombustion techniques), metals (trace impurities); radio chemistry; chemical services, including testing of effluents and control of chemical processes—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.485/53A.

EXPERIMENTAL OFFICER and an ASSISTANT EXPERIMENTAL OFFICER (with a degree in agriculture, botany or chemistry) AT THE GRASSLANDS RESEARCH INSTITUTE, Hurley, Maidenhead, and Drayton, Stratford on Avon, to assist in experimental work on the development of grass roots, grazing experiments or in the chemistry department—The Secretary, Grassland Research Station, Hurley, Maidenhead.

HONOURS GRADUATE (with experience in use of infra-red spectrophotometer) required to assist in programme of research on various substances isolated from dairy products—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/14.

JUNIOR ASSISTANT CHEMIST (with at least a pass degree in subjects which must include chemistry) for work at Tilbury in connexion with a survey of the Thames Estuary—The Establishment Officer, Port of London Authority, Trinity Square, London, E.C.3.

JUNIOR RESEARCH ENGINEERS (with good honours degree) for (*a*) general automobile engineering problems; (*b*) for investigations concerning mechanical properties (in particular fatigue strength) of materials and components; RESEARCH ASSISTANTS (H.N.C. or equivalent qualifications) for general automobile engineering problems—The Director, Motor Industry Research Association, Lindley, near Nuneaton.

LECTURER and an ASSISTANT LECTURER (with special knowledge of cytology, genetics, ecology, taxonomy or anatomy) IN BOTANY—The Registrar, The University, Nottingham.

PHYSICISTS (with good honours degree, and some experience in training or research) for work on textile problems—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, near Manchester.

PHYSIOLOGIST (with good honours degree in physiology or equivalent qualification, and research experience, preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/3.

SENIOR AGRICULTURAL OFFICER (Irrigation) (with a degree in agricultural science and practical experience of the operation of irrigation schemes) with the Gold Coast Government—Commissioner for the Gold Coast, Melbourne House, Aldwych, London, W.C.2.

SENIOR LECTURER (preferably with higher degree in either agricultural, veterinary or pure science) IN PHYSIOLOGY OF THE SHEEP, at the Massey Agricultural College, Sheep Husbandry and Wool Department, to lecture on the physiology of growth and reproduction in the sheep and the nutrition of sheep—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, or The Registrar, Massey Agricultural College, Palmerston North, New Zealand.

SENIOR LECTURER IN TECHNICAL CHEMISTRY—The Secretary, Royal Technical College, George Street, Glasgow, C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

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Report by the Hydrographer of the Navy on the Surveys carried out by H.M. Naval Surveying Service, and of the work of the Hydrographic Department for the Year 1952. Pp. 10. (London: Admiralty, Hydrographic Department, 1953.) [128

British Museum (Natural History). Fossil Mammals of Africa No. 6: The Miocene and Pleistocene Lagomorpha of East Africa. By D. G. MacInnes. Pp. ii+30+1 plate. (London: British Museum (Natural History), 1953.) 10*s*. [128

Department of Scientific and Industrial Research. Report of the Radio Research Board with the Report of the Director of Radio Research for the Year 1952. Pp. iv+51. (London: H.M. Stationery Office, 1953.) 2*s*. net. [138

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Fitzwilliam Museum, Cambridge. Annual Report for the Year ending 31 December 1952. Pp. 5+4 plates. Friends of the Fitzwilliam Museum. Forty-Fourth Annual Report for the Year 1952. Pp. 8. (Cambridge: Fitzwilliam Museum, 1953.) [138

Evidence of a Relationship Between the Patient and his Blood Specimen. Pp. 4. (Oxford: Delawarr Laboratories, Limited, 1953.) 1*s*. [178

British Trust for Ornithology. Nineteenth Annual Report, 1952. Pp. 65. (Oxford: British Trust for Ornithology, 1953.) 2*s*. 6*d*. [178

Freshwater Biological Association. Twenty-first Annual Report, for the Year ending 31st March, 1953. (Including Reports of the Council and the Director and Accounts for 1952–53 with Lists of Officers, Council, Staff and Members.) Pp. 53. (Ambleside: Freshwater Biological Association, 1953.) 3*s*. to non-members. [178

Colonial Office. Report on a Melanau Sago Producing Community in Sarawak. By H. S. Morris. Pp. vi+184. (London: H.M. Stationery Office, 1953.) 11*s*. 6*d*. [178

The B.N.F. Jet-Test for Local Thickness Measurements of Electrodeposited Metallic Coatings. Pp. 28. (Poole: British Drug Houses, Ltd., 1953.) [178

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A Scientific Survey of Merseyside. Edited by Prof. Wilfred Smith, assisted by F. J. Monkhouse and H. R. Wilkinson. (British Association for the Advancement of Science, 1953.) Pp. xv+299+8 plates. (Liverpool: University Press of Liverpool, 1953.) [218

City of Leicester Museum and Art Gallery. 46th Report to the City Council, 1st April, 1951, to 31st March, 1952. Pp. 37. (Leicester: City of Leicester Museum and Art Gallery, 1953.) [218

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations. Season 1951–52, Tanganyika Territory, Eastern Province (Covering Seasons 1950, 1951 and 1952). By A. G. Bebbington and H. J. de S. Disney. Pp. 15. 9*d*. Survey of Reports. Season 1951–52. By J. B. Hutchinson. Pp. 12. 9*d*. (London: Empire Cotton Growing Corporation, 1953.) [243

Privy Council. Medical Research Council, Special Report Series. No. 278: Psychotic and Neurotic Illnesses in Twins. By Eliot Slater, assisted by James Shields. Pp. vi+385. (London: H.M. Stationery Office, 1953.) 21*s*. net. [248

Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. No. 647, Vol. 237: Some British Lower Paleonzoic Conodont Faunas. By Dr. F. H. T. Rhodes. Pp. 261–334 + 4 plates. (London: Cambridge University Press, 1953.) 22*s*. [248

Colonial Office. Fishery Publications. Vol. 1, No. 3, 1953: Report on the Mauritius–Seychelles Fisheries Survey, 1948–1949. Part 1: The Bottom Fishes of Economic Importance. By J. F. G. Wheeler. Part 2: The Pelagic Fishes and a note on Tow Nettings. By F. D. Ommanney. Part 3: Note on Meteorology. By F. D. Ommanney. Part 4: General Considerations and Conclusions. By J. F. G. Wheeler. Pp. ii+145+5 plates. (London: H.M. Stationery Office, 1953.) 40*s*. net. [258

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Indian Forest Bulletin No. 165. (New Series.) Cellulose and Paper: Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board. Part 14: Chemical Pulps and Writing and Printing Papers from *Sterculia campanulata*, Wall. By R. V. Bhat and K. C. Virmani. Pp. ii+10. (Delhi: Manager of Publications, 1953). 12 annas; 1*s*. [78

New Zealand. Department of Scientific and Industrial Research. Seismological Observatory, Wellington, W.1. Seismological Report for July, August, September, 1950. Pp. 19. (Bulletin E. 121.) (Wellington: Government Printer, 1953.) [128

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Department of the Army: Corps of Engineers. Beach Erosion Board. Technical Memorandum No. 36: Wave and Lake Level Statistics for Lake Michigan. By Thorndike Saville, Jr. Pp. iv+108. Technical Memorandum No. 37: Wave and Lake Level Statistics for Lake Erie. By Thorndike Saville, Jr. Pp. iv+88. Technical Memorandum No. 38: Wave and Lake Level Statistics for Lake Ontario. By Thorndike Saville, Jr. Pp. iv+64. (Washington, D.C.: Office, Chief of Engineers, 1953.) [178

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Publications of the United States Naval Observatory. Second Series. Vol. 16, Part 3: Results of Observations made with the Six-inch Transit Circle, 1941–1949. Observations of the Sun, Moon, and Planets; Catalog of 5,216 Stars for 1950.0; Corrections to GC and FK3. By C. B. Watts, F. P. Scott and A. N. Adams. Pp. 363–591. (Washington: Government Printing Office, 1952.) [178

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Beck Microscopes. Pp. 88. (London: R. and J. Beck, Ltd., 1953.)

"Pyrex" Laboratory and Scientific Glassware. Pp. 123. (Sunderland: James A. Jobling and Co., Ltd., 1953.)

Permanent Magnets. Pp. 64. (London: Mullard, Ltd., 1953.)

Components and Materials. Ferroxcube. Pp. 46. (London: Mullard, Ltd., 1953.)

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Zenith Variac Transformers for Voltage Control. Pp. 6. (London: Zenith Electric Co., Ltd., 1953.)

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